JOURNAL

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FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXX. JULY, 1875. No. 1.

EDITORIAL.

ITEMS AND NOVELTIES.

The Commission on Water Supply of the City of Philadelphia.—The Commission of Civil Engineers appointed by the Mayor met together at the Franklin Institute, on the 29th of June, and organized by the election of W. Milnor Roberts, as Chairman. The ordinance of Councils makes it the duty of this commission to examine and report upon the present and future water supply of the city of Philadelphia. The commission consists of the following gentlemen: W. Milnor Roberts, C.E., of New York; Hon. Wm. J. McAlpine, C.E., of Albany; Col. Julius W. Adams, C.E., of Brooklyn; S. W. Roberts, C.E., of Philadelphia; Wm. E. Morris, C.E., of Philadelphia; who, according to the ordinance, act in conjunction with Dr. Wm. H. McFadden, Chief Engineer of the City Water Department.

We learn that these gentlemen, ever since their organization as a commission, have been almost constantly engaged in the performance of the very important and responsible duty which has been assigned to them. They have visited and examined all the pumping works

at Fairmount, Spring Garden, Belmont, Roxborough, Chestnut Hill, and Kensington, and the Fairmount, Belmont, Roxborough, Chestnut Hill, Mount Airy, Germantown, Lehigh Avenue and Corinthian reservoirs; also the large unfinished reservoir in East Park. They have also made special examinations of the Wissahickon Valley, of the Valley of the Perkiomen, and of the proposed reservoir site in that valley, in company with Mr. Birkinbine, former Chief Engineer of the Water Department, who recommended its construction, in reports made by him about ten years ago.

The members of the commission, by invitation of Mr. Gowen, President of the Reading Rail Road Company, who kindly placed special engines at their disposal, made a very satisfactory visit to the upper Schuylkill, accompanied by James F. Smith, Chief Engineer of the Schuylkill Navigation Co., who showed and explained the Company's reservoirs at Tumbling Run. They made an examination of the Delaware river, accompanied by Mayor Stokley, as far up as Beverly, a few miles above the city boundary, making special observations at all important sewage and creek outlets. Afterward, members of the commission examined the Delaware river above tide, particularly at New Hope, Easton, and the Delaware Water Gap. They visited Ewing's Spring, which is 2½ miles from New Hope. They also made an examination of the Schuylkill river, between Fairmount dam and Spring Mills, passing through the locks of the Navigation Company, and visited the fine spring near Spring Mills.

The commission have requested the Chief Engineer of the Water Department to have rapid surveys made from the Perkiomen, and from the vicinity of New Hope to the city, to enable them to judge correctly of the nature and extent of the obstacles in the way of possible lines of conduit. Meanwhile, the members, whether in session or otherwise, are almost constantly engaged in collecting and collating data to aid them in their investigations.

It is well known to those who are familiar with the water system of Philadelphia, that it is one of peculiar complication; owing not so much to the topography as to the comparatively late consolidation into one, of a number of separate municipal or civil corporations, each having its own water supply arrangement.

The object of the commission is to ascertain what is most advantageous for the immediate demands of the city; and, which is still more important, what is the best plan or plans for the future.

While much preliminary work has already been accomplished by the commission, some time will necessarily be required to arrange the various data, which are daily accumulating, as well as for their complete study and discussion before any definite conclusions can be reached.

We learn that at the request of the commission our fellow-townsman, Mr. Jas. Haworth, appeared before them and presented some views, in addition to those he has before made public in several pamphlets.

The Chief Engineer of the Water Department, and his assistants, have been kept busy in preparing statistics of various kinds, relating to the subject, for the use of the commission, and in making measurements of the flow of certain streams. It is obvious that the matter is in the hands of gentlemen competent to fulfill the duty assigned to them, and that they have entered upon their labors with a determination to make their investigations in the most thorough manner.

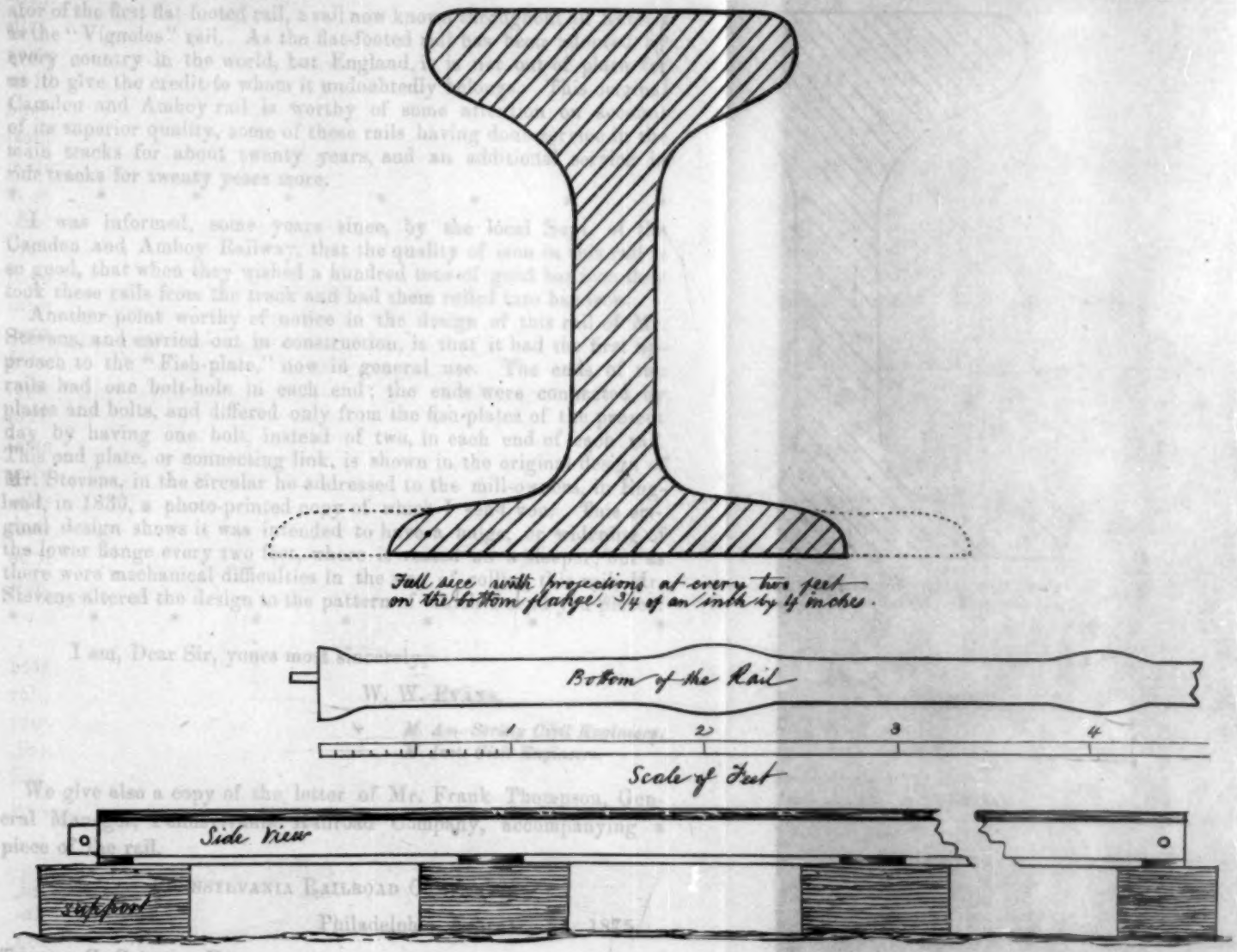
Elgerton's Oxy-Hydro-Carbon Light.—At the June meeting of the Institute, this invention was exhibited and described. It consists of a small copper vessel, placed immediately over the flame of a jet, arranged as in the ordinary oxy-hydrogen light and so connected with a reservoir that hydro-carbon oil can be fed into it as required. The heat of the flame converts the oil into vapor of high tension, which is carried to a chamber of about one-half cubic inch capacity at the base of the jet where it mingles with oxygen and is burned in the ordinary jet, and the flame projected against a piece of lime, as in the oxy-hydrogen light. In order to start the light it is necessary to first heat the generator with a spirit lamp, until vapor is produced, when the oxygen is turned on and the spirit lamp withdrawn. The inventor claims that the light thus produced is more brilliant and cheaper as well as more convenient, where it is difficult to obtain ordinary illuminating gas.

American Association for the Advancement of Science.—From the circular just issued by Professor Putnam, the permanent secretary, we learn that the twenty-fourth annual meeting of the American Association for the Advancement of Science will open at Detroit, on Wednesday morning, August 11th, 1875, at ten o'clock. Present appearances indicate one of the largest meetings the associa-

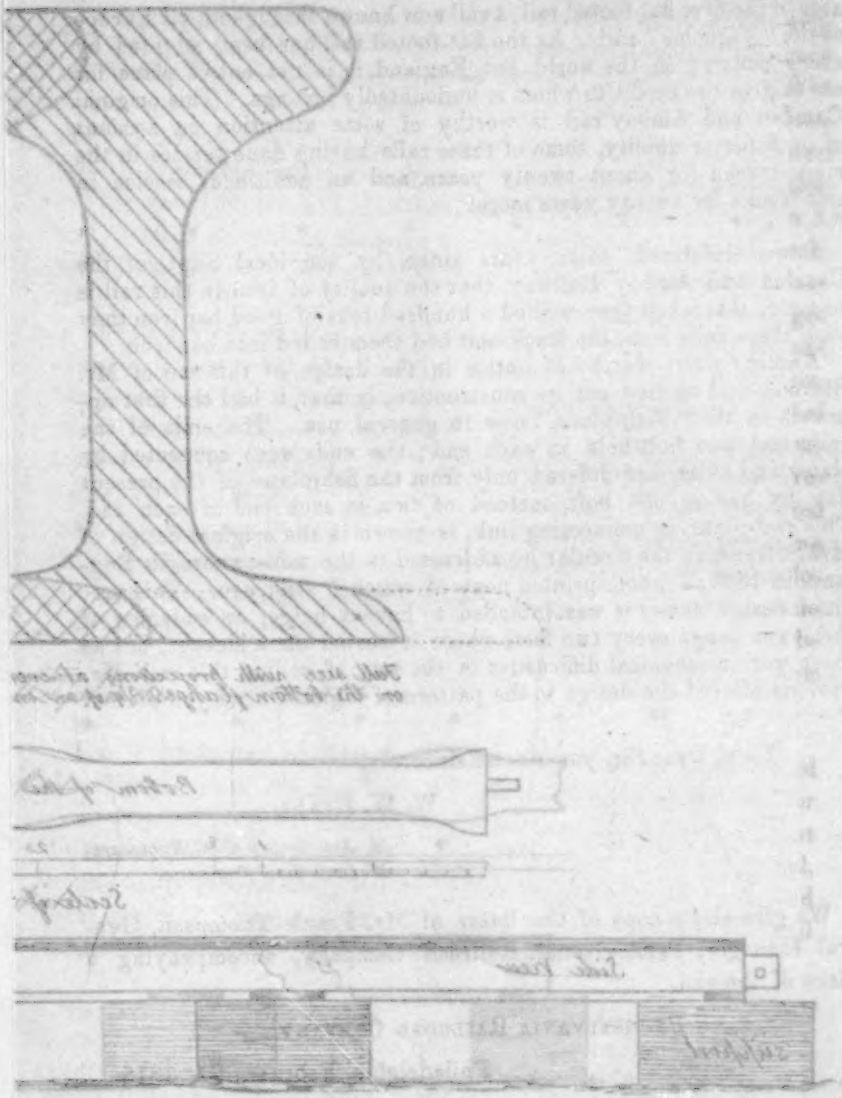
tion has ever held. As it is the first meeting under the new constitution, adopted at Hartford, it is believed that many of the evils noticeable in former meetings will be remedied, and that the efficiency of the association as a whole will be largely increased. It will be remembered that at the chemical centennial, held at Northumberland last year, a movement was made toward the formation of a chemical section in the American Association. At Hartford, the proposition was favorably received, and a permanent sub-section of Section A was formed, devoted to chemistry, chemical physics, chemical technology, mineralogy, and metallurgy. It is hoped that all who are interested in the above subjects, especially those who are engaged in the larger chemical and metallurgical industries, will be present at Detroit and make the new sub-section of chemistry a success. The officers of the sub-section are permanent officers, being elected at the meeting previous to the one at which they are to serve. Professor S. W. Johnson, of Yale College, is President, and Professor F. W. Clarke, of Cincinnati, is Secretary of the Chemical sub-section for the Detroit meeting. Beside this, a special gathering of Entomologists is expected, and the entomologists and archæologists intend to organize a section of anthropology. The local organization at Detroit is most complete, and it is clear that nothing will be wanted to make the meeting a noteworthy one socially, as it now promises to be intellectually.

The Flat-footed or Tee Rail.—The following letter addressed to the President of the Institute was read at the stated meeting, for June, and will prove of interest as it seems to establish beyond doubt the fact of Mr. Stevens being the original designer of the flat-footed, or, as it is more commonly known in this country, the Tee rail, and not Charles B. Vignoles, late President of the Institute of Civil Engineers of England, as is commonly believed in Europe.

Dear Sir:—I herewith send you two pieces of rail, one nickled, the other plain, just as cut from the rail. I present them to the Institute as specimens of what we may call an historical rail; they are cut from one of the first flat-footed rails ever rolled. This rail was designed in 1830, by Robert L. Stevens, of New Jersey, for the Camden and Amboy Railway, was rolled in 1831, and laid in 1832. Many of these rails I saw laid. I now bring this rail to your attention, chiefly to show that Mr. Stevens was the designer and origin-



FAC-SIMILE OF THE ORIGINAL DESIGN, BY MR. ROBERT L. STEVENS, OF THE FLAT-FOOTED RAIL, TAKEN FROM A CIRCULAR ADDRESSED TO MILL OWNERS IN ENGLAND, IN 1830.



ator of the first flat-footed rail, a rail now known throughout all Europe as the "Vignoles" rail. As the flat-footed rail has been adopted by every country in the world, but England, it is not out of place for us to give the credit to whom it undoubtedly belongs. This original Camden and Amboy rail is worthy of some attention on account of its superior quality, some of these rails having done service in the main tracks for about twenty years, and an additional service in side tracks for twenty years more.

* * * * * * * *

I was informed, some years since, by the local Supt. of the Camden and Amboy Railway, that the quality of iron in this rail is so good, that when they wished a hundred tons of good bar iron they took these rails from the track and had them rolled into bar iron.

Another point worthy of notice in the design of this rail of Mr. Stevens, and carried out in construction, is that it had the first approach to the "Fish-plate," now in general use. The ends of the rails had one bolt-hole in each end; the ends were connected by plates and bolts, and differed only from the fish-plates of the present day by having one bolt, instead of two, in each end of each rail. This end plate, or connecting link, is shown in the original design of Mr. Stevens, in the circular he addressed to the mill-owners, in England, in 1830, a photo-printed copy of which I send you. This original design shows it was intended to have a bulge, or widening of the lower flange every two feet, where it rested on a sleeper, but as there were mechanical difficulties in the way of rolling this rail, Mr. Stevens altered the design to the pattern of which I send you pieces.

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I am, Dear Sir, yours most sincerely,

W. W. Evans,

M. Am. Society Civil Engineers.
M. Inst. Civil Engineers.

We give also a copy of the letter of Mr. Frank Thompson, General Manager, Pennsylvania Railroad Company, accompanying a piece of the rail.

Pennsylvania Railroad Company.

Philadelphia, February 27, 1875.

Thomas C. Clarke, Esq.

Dear Sir:—I take pleasure in forwarding you one yard of the rail known as Mr. Stevens' pattern, laid in 1832 on the Camden and Amboy Railway. The following is a quotation from a letter from the Superintendent of the Amboy Division, indicating that the rail has really been in service for about 40 years.

"No record to enable us to tell when the piece of iron was taken from the main track. My recollection is that it was all replaced about 1852 or 1853. The piece sent you was probably on the main track for about twenty years, and in a siding for about twenty years more."

"Yours, Respectfully,

"FRANK THOMPSON, *General Manager.*"

The cuts given are fac-similes of the drawings in the circular sent to mill owners by Mr. Stevens in 1830.

Water Works and Drainage at Atlantic City.—The geological formation of the island on which Atlantic City is situated, does not furnish water suitable for cooking and drinking, and it has been necessary to use rain water stored in cisterns for these and other domestic purposes. This source of supply being both expensive and unreliable, and the want of an ample supply of water as protection against fire, has led the Camden and Atlantic Railroad Co. to take steps towards the erection of water works.

It is proposed to take the water from Absecom Creek, at the grist mill of A. Doughty, situated about 8 miles from Atlantic City, where there is a fall of 5 feet. At this point it is proposed to place two turbine wheels, each driving two piston pumps, forcing the water through a 16-inch main pipe, to a standpipe 14 feet in diameter, and 100 feet high, located at some convenient point in the town.

These pumps are to have a combined capacity of 500,000 gallons per day, under a head of 80 feet in the standpipe, which will be an ample supply for 9 months of the year. The two wheels will be so controlled by a governor, operated by the pressure in the main pipe, that both will run until the head reaches 80 feet, when one will stop and remain so as long as the other can maintain it at that point. The second wheel will continue to run until the head reaches 100 feet, when it also will stop—the wheels starting again as the head falls below the points named.

A larger supply being required during the summer and in case of fire, there will be located in the town, near the standpipe, a steam pumping engine, which shall take suction from the 16-inch main, and maintains a head of 100 feet in the standpipe, the water wheels running at the same time to overcome the friction in the eight miles of main pipe.

For fire service, the connection with the standpipe will be cut off,

and the water forced directly through the distributing main under a pressure of one hundred pounds per square inch, which will be sufficient to throw water over the highest buildings, by connecting the hose directly to the hydrants. The arrangement by which this change is made, and the governor controlling the action of the water wheels, are the inventions of Mr. H. P. M. Birkinbine, by whom the designs for the entire works are being prepared. The whole cost of the works, not including the real estate, is estimated at $180,000. The Railroad Co. asks the co-operation of the citizens and property owners, both for the raising of the funds and that they may have a voice in the management of the works, but we are informed that it will probably build the works even if the citizens do not take part in the enterprise.

Another much needed improvement is the main sewer proposed to be built, beginning at a point near where the road bridge crosses Beach-thoroughfare, thence through Florida, Atlantic, and Massachusetts Avenues to Clam Creek, a distance of 13,000 feet. The bottom of this main sewer is to be one foot below low tide, and to be five feet high in the clear. The distance between the ends of this sewer by the course it takes, being about three miles less than by the channel of the natural water course, it is believed that the ordinary flow will keep it clear, but to secure a more certain and rapid action, it is designed to construct gates or valves at either end of the sewer, to be closed when the tide is high and the sewer full of water, and opening them alternately when the tide is low. This system of flushing, we are told, has been in use for several years in Charleston, and has proved very satisfactory. The total cost of the main sewer is estimated at from seventy to ninety thousand dollars. The branch sewers to be paid for by the property immediately benefited.

K.

Paton and Harris' Pyroletor, for the Extinction of Fire on Board Ships.—Under the supervision of Dr. R. Carter Moffat, who conducted the experiments, a large party of gentlemen connected with shipping and the Board of Trade assembled at Greenhithe, near Gravesend, recently, to witness the power of the pyroletor to extinguish fire in closed places. The pyroletor consists of a small double pump worked by hand, which sucks up from tubes on either side of it strong muriatic acid and a solution of bicarbonate of soda, which

commingle in a generator forming part of the pump, and the carbonic acid gas and solution of salt pass at once down a metal pipe to the hold, along whose keelson runs a perforated wooden box which admits of the gas passing through to the burning material. The agent, therefore, for the extinction of fire is dry carbonic acid gas, which has no action on cargo. A well-appointed steamer conveyed the party from Blackwall to Greenhithe, where a large wooden barge had been prepared for the experiments. Its entire hold was covered to a depth of several feet with wood shavings, cotton-waste saturated with turpentine, and naphtha. A temporarily-raised and by no means air-tight wooden deck, with loosely-fitting boards, formed the wide hatch-way covering. After the apparatus had been explained by Dr. Moffat, its action as a common wash-deck pump and fire-engine for fire above board had been observed, when it acted very efficiently, throwing water a distance of at least 30 feet, the pipes to the chemicals were attached, and the signal given to set fire to the inflammable materials in the hold. Immediately the flames ran along the entire cargo and issued above the temporary deck, which was then covered with boarding. The pyroletor having been brought into action, and although nearly half a gale of wind was blowing, the fire was completely extinguished in four minutes. The experiments were so completely successful, and the efficiency of the apparatus so apparent, that the party at once agreed to sign a memorial to ask Government to compel all long-passage ships conveying passengers and cargo to carry one of these instruments. It is computed that a 1200-ton ship requires about half-a-ton of each of the chemicals, which, with their packages, cost about £20.—*Chemical News.*

Franklin Institute.

HALL OF THE INSTITUTE, June 16th, 1875.

The stated meeting of the Institute was called to order at 8 o'clock, P. M., Vice-President B. H. Moore in the chair.

The attendance was very large, the room being crowded to excess, and many members not able to gain admittance.

The minutes of the stated meeting for May were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at their meeting held on the 9th inst., there were 12 persons elected members, and the following donations made to the library:

Report of the Superintendent of the United States Coast Survey, showing the Progress of the Survey during the year 1871. Washington, 1874. From C. P. Patterson, Supt. U. S. C. S.

Report of the Permanent Committee of the First International Meteorological Congress at Vienna, for the year 1874. From the Meteorological Committee. London.

Notes on Public Works in the United States and Canada, including a description of the St. Lawrence and Mississippi Rivers and their Main Tributaries. By Sir Charles A. Hartley, M. Inst. C.E. From the Author.

Bulletin of the United States Geological and Geographical Survey of the Territories. Bulletin No. 2. From the Department of the Interior. Washington.

Bulletin of the United States Geological and Geographical Survey of the Territories. Bulletin No. 3. From the Department of the Interior. Washington.

Ueber die Wasserabnahme in den Quellen, Flüssen und Steomen bei gleichzeitiger Steigerung der Hochwasser in den Culturlandern. Von Gustav Wex. Wein, 1873. From the Author.

Annales des Ponts et Chaussées, for May, 1875. From the Editor. Paris.

Annual Report of the Committee of Management of the Manchester Steam Users' Association, 1874. From the Association.

Annual Report of the Chief Engineer of the Water Department of the City of Philadelphia, for the year 1874. From Wm. H. McFadden, Chief Engineer.

Minutes of the Proceedings of the Institution of Civil Engineers, with other selected and abstracted papers. Vol. 39. By James Forrest. From the Society.

English Patent Specifications for 1873 and 1874, with an Index of Patents and Patentees for 1872. And the following Abridgements of Specifications:

Milking, Churning and Cheese-Making, A. D. 1777-1866. London, 1874.

Drains and Sewers; including the Manufacture of Drain Tiles and Pipes. A. D. 1619-1866. London, 1874.

Anchors, A. D. 1796-1866. London, 1874.

Mining, Quarrying, Tunneling and Well Sinking, A. D. 1688-1866. London, 1874.

Masts, Sails, Rigging, etc., including apparatus for raising and lowering ship's boats, A. D. 1625-1866. London, 1874.

Wearing Apparel, Division 1. Head Coverings, A. D. 1637-1866. London, 1874.

Metallic Pipes and Tubes, A. D. 1741-1866. London, 1874.

Electricity and Magnetism; their generation and applications. Part 2. A. D. 1858-1866. London, 1874.

Hydraulics, A. D. 1617-1866. London, 1874. From the Commissioner of Patents of Great Britain.

Index to the Commissioner of Patents Journal, for 1874. Index to Foreign Scientific Periodicals contained in the Free Public Library of the Patent Office. Indexes of Authors and Subjects for 1872. Chronological and Descriptive Index of Patents applied for, and Patents granted, in 1874. List of Specifications and other Publications issued weekly, for 1874. From the Commissioner of Patents. Great Britain.

Lecture on the late Improvements in Steam Navigation and the Arts of Naval Warfare, with a brief notice of Ericsson's Caloric Engine. By John O. Sargent. From Mary A. Cox. Philadelphia.

Observations on the best means of Propelling Ships. By Alexander S. Byrne. New York, 1841. From Mary A. Cox. Phila.

The Actuary also reported that in accordance with the recommendation of the Committee on Science and the Arts, the Board of Managers have awarded the Scott Legacy Medal and Premium to E. A. Goodes for his improvement in Sewing Machines.

The Secretary read a letter from W. S. Stokley, Mayor of the city, transmitting to the Board a certified copy of the following ordinance, approved June 5th, 1875.

"An ordinance to appoint a commission on supply of water of the City of Philadelphia:

"Sec. 1. The Select and Common Councils of the City of Philadelphia do ordain, That the Mayor be requested to appoint a Commission of five scientific and practical engineers, to be selected by

him from not less than eight names, which are to be recommended by the Board of Managers of the Franklin Institute, to whom, in connection with the Chief Engineer of the Water Department, shall be referred the entire subject of the present and future water supply of the City of Philadelphia, and to report their views to Councils.

"SEC. 2. That the sum of one thousand dollars be, and the same is hereby appropriated to pay the expenses of the above commission, and warrants shall be drawn by the Chief Engineer of the Water Department in conformity with existing ordinances."

The following communication to the Mayor, showing the action taken by the Board, was also read:

Franklin Institute, June 10th, 1875.

"To the Honorable W. S. Stokley, Mayor of Philadelphia:—

"Sir: I have the honor to transmit herewith the names of the eight engineers, recommended by the Board of Managers of the Franklin Institute, at a meeting held June 9th, 1875, in accordance with an ordinance to 'Appoint a commission on Supply of Water for the City of Philadelphia,' approved June 5th, 1875.

"The names are as follows:

FAIRMAN ROGERS,	JAMES E. SMITH,
WM. E. MORRIS,	SOLOMON W. ROBERTS,
W. MILNOR ROBERTS,	W. HASSEL WILSON,
FREDERICK GRAEF,	WM. J. MCALPINE.

Respectfully,

D. S. HOLMAN, *Actuary.*

The Secretary also read the following, from the minutes of the meeting of the Board, held on the 1st inst.

"The Treasurer reported that he had received to-day, from the executors of Asa Whitney, twelve shares of the stock of the Railway Equipment Trust of Pennsylvania, for one thousand dollars each, bearing eight per cent. per annum interest, and five hundred dollars in cash, making in all twelve thousand five hundred dollars, being in full for the legacy given to the Institute by the will of Mr. Whitney; and that the family of Mr. Whitney had paid the collateral inheritance tax on said legacy, amounting to six hundred and twenty-five dollars, whereby the Institute had received the whole amount of the benefaction, free of any charge.

"And, on motion of Mr. Fraley, it was

"*Resolved*, That the Secretary of the Institute be requested to present thanks to the family of Mr. Whitney for their liberal gift of the collateral inheritance tax on the legacy of Mr. Whitney, and to acknowledge the receipt of the bequest as reported by the Treasurer."

The Secretary stated that the printing of the Report of the late Exhibition had so far progressed that it will be ready for distribution in a few days.

The Secretary then presented his Report on Novelties in Science and the Mechanic Arts, which embraced a paper barrel, the invention of M. N. Keely; a new street car starter, the joint invention of Chas. J. Shain and Geo. L. Waite; a new method of canceling postage stamps, invented by John Shinn; a new mail bag fastener, by Geo. O. Clark; an automatic car brake, by Thos. E. Thompson; and a piece of flat-bottomed or Tee rail, from one of the first ever made, having been designed by Robt. L. Stevens in 1830, rolled in 1831, and laid on the Camden and Amboy Railroad in 1832, and had been in service 40 years.

The Secretary then described with the aid of diagrams and pictures on the screen, the fall of the bridge across the Big Black River, on the line of the railroad leading from Vicksburg to Jackson, Miss.*

The Secretary projected on the screen a number of views, showing the progress on the Centennial Buildings, and also described his improved method of illustrating the dissection or negative crystallization of ice.

Prof. Geo. F. Barker was then invited to describe his new Lecture Galvanometer, which he did, giving a number of illustrations of its delicacy and general adaptability to lecture purposes.

The new oxy-hydro-carbon light, invented by N. H. Edgerton, was described, and its illuminating power, as compared with the lime light, was shown by projecting pictures on the screen.

Prof. Barker then described and gave some illustrations of the power of the Gramme Magneto-Electric Machine, which was placed on the stage and driven by a Shapley steam engine; both of which will be found described in the JOURNAL for June, 1875.

On motion the meeting then adjourned.

J. B. KNIGHT, *Secretary.*

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* An account of this, by Wm. E. Morris, C.E., will be found elsewhere in this No. of the Journal.

The Challenger's Scientific Work in the West Pacific.—The following is a short account of the scientific work of the Challenger in the West Pacific Ocean:—

We established seven deep-sea observing stations between Mindanao and the Admiralty Islands, and at each of these we sounded, took samples of the bottom, took a series of temperatures at different depths, and got specimens of water from surface, the bottom, and intermediate depths, for the determination of the specific gravity and for chemical analysis. At five of the seven stations, the trawl was sent down and a fair representation of the deep-sea fauna was procured. The greatest depth on this line—2,500 fathoms—we found between the Molucca Passage and the Pellew Islands. The samples of bottom varied in character according to the depth, very much as in the Atlantic. The average temperature of the sea surface during this part of the cruise was 82·5 deg. Fahrenheit. The serial temperature soundings seem to show that a great part of the Western Pacific is not entirely in free communication with the Southern Sea, for the water, after sinking rapidly in temperature until it reaches 34·5 deg. Fahr., at a depth of 1,500 fathoms, maintains that temperature for all the greater depths. The section from the Philippines to the Admiralty Islands may be considered to have been taken, roughly, along the Equator, as it was all between lat. 5 deg. N. and lat. 3 deg. 3 min. S. The section, 2,250 miles long, from the Admiralty Islands to Japan, was practically meridional. The observing stations in the second section were 12 in number, and pretty regularly distributed with regard to distance. The greatest depth was found on the 23rd of March in 4,575 fathoms. This is the deepest trustworthy sounding on record, with the exception of two taken by the Tuscarora, off the east coast of Japan, in 4,643 and 4,655 fathoms respectively, but no sample of the bottom was procured on either of these occasions. The sounding in 4,575 fathoms was taken in the morning. Only a very small sample of the bottom came up, and the depth was so unexpected that it was decided to repeat the sounding to avoid all possibility of error. In the meantime the ship had drifted a little, and the second sounding, which was most satisfactory in every respect, gave 4,475 fathoms. The tube of the sounding machine contained an excellent sample of the bottom, which was of a very peculiar character, consisting almost entirely of the siliceous shells of *Radiolaria*. Three out of four Miller-Casella thermometers sent down to these depths

were crushed to pieces by the enormous pressure they had to bear—between five and six tons on the square inch; the fourth withstood the pressure, and registered, when corrected for the pressure, at 1,500 fathoms, the usual temperature for that depth, 34·5 deg. Fahr., so that at that place there is a layer of water at that uniform temperature occupying the bottom of the ocean trough of the enormous thickness of 3,075 fathoms (18,450 feet). The soundings in this section were usually deep. They commenced near Admiralty Island, with a depth of 1,100 fathoms, and a characteristic globigerina ooze. The next sounding gives us "red clay" at 2,670 fathoms, and this is continued at like depths until we reach the western verge of the Carolines, where we have "gray ooze" at 2,325 fathoms and "globigerina ooze" at 1,850. Between the Carolines and the Ladrones there is the sounding in 4,575 fathoms, "red clay," with its character almost entirely masked by the quantity of siliceous shells. We then pass again into typical "red clay" which covers a vast plateau, almost level, at 2,400 fathoms, extending from lat. 15 deg. N. to Japan. The observations made in this section, taken in connection with others made elsewhere, would seem to point to the following law:—That "globigerina ooze"—a rapidly forming deposit, containing the whole of the abundant carbonate of lime of the shells of the foraminifera living on the surface and beneath it, and consequently consisting of almost pure carbonate of lime—generally occupies depths under 2,000 fathoms in the ocean; that beyond this depth, the proportion of the calcareous matter is gradually diminished, and the doposit, which now contains a considerable amount of clay, goes under the name of gray ooze; that at 2,600 fathoms the calcareous matter has almost entirely disappeared, and we have the purest form of "red clay," a silicate of alumina and iron with siliceous tests of animals; that from this point the "clay" decreases in proportion, and the siliceous shells increase, until at extreme depths the "clay" is represented by little more than a red cement, binding the shells together. As to the transition from the "globigerina ooze" to the "red clay," it is due to the removal of the lime of the globigerina shells by water and carbonic acid, or in some other way; the apparent disappearance of the "red clay" is a fallacy produced by the increased proportion of the siliceous shells. It has now been ascertained by the use of the tow-net at great depths that radiolarians and diatoms inhabit the water all the way down, and are probably

more abundant at greater depths, and it follows from this that four times more, at least, must die and shed their tests in 4,000 fathoms than in 1,000 fathoms.

The most marked temperature phenomenon observed in these two sections was the presence of a surface layer of water of an average depth of 80 fathoms, and a temperature above 77 deg. Fahr., extending northwards from the coast of New Guinea about 20 deg., and westward as far as the meridian of the Pellew Islands. The greater part of this huge mass of warm water is moving with more or less rapidity to the westward. The trawl was used seven times between New Guinea and Japan, but, owing to the great depth and the nature of the sea-bottom, the results were not large. Nearly every haul brought up, besides a few of the characteristic deep-sea creatures, lumps of water-logged pumice, many of them with small shells attached.—*English Mechanics' World of Science.*

Preservation of Plaster Casts.—Sir, The thorough saturation of plaster in melted paraffin will, I have reason to believe, preserve it from the weather in this country. An example so treated by me lay for some years on a marble block, in my garden here, in the open air, and remained uninjured. On the occasion, a good many years since, of a fancy fair for the benefit of the Female School of Art, connected with South Kensington, I contributed several specimens of small art works thus treated. This application of paraffin to plaster works of art was subsequently to this tried on a larger scale at South Kensington, without however any consultation with me, but from the want of proper treatment, it resulted in failure. The examples I have, and am ready to show, are apt to get rather too yellow, like yellow ivory, but my friend, Mr. G. F. Wilson, F.R.S., who obtained the paraffin for me in the first instance, tells me he thinks that if it were quite pure, it would retain its color.

The mode of saturation is no secret, as it is similar to that employed in the saturation of plaster casts in stearine. I am, etc.,

JOHN BELL.

15 *Douro Place, Victoria-road, Kensington, W, June* 12, 1875.

P. S.—The paraffin hardens the plaster so much that the nail will scarcely scratch it. It increases its weight considerably, and gives it an appearance approaching transparency, like ivory, and preserves it in repeated washings.—*Journal of the Society of Arts.*

Centennial Exhibition.—The Art Gallery, of which we give illustrations, is a permanent building, the funds for its erection having been appropriated by the State of Pennsylvania and the City of Philadelphia, on condition that it shall remain as a memorial of the great exhibition. It is located on a line parallel with and northward of the Main Exhibition Building, on the most commanding portion of great Lansdowne Plateau and looks southward over the city. It is elevated on a terrace six feet above the general level of the plateau—the plateau itself being an eminence 116 feet above the surface of the Schuylkill River. The entire structure is in the modern renaissance. The materials are granite, glass and iron, no wood being used in the construction, the building is thoroughly fire-proof. It is 365 feet in length, 210 feet in width, and 59 feet in height, over a spacious basement 12 feet in height, surmounted by a dome.

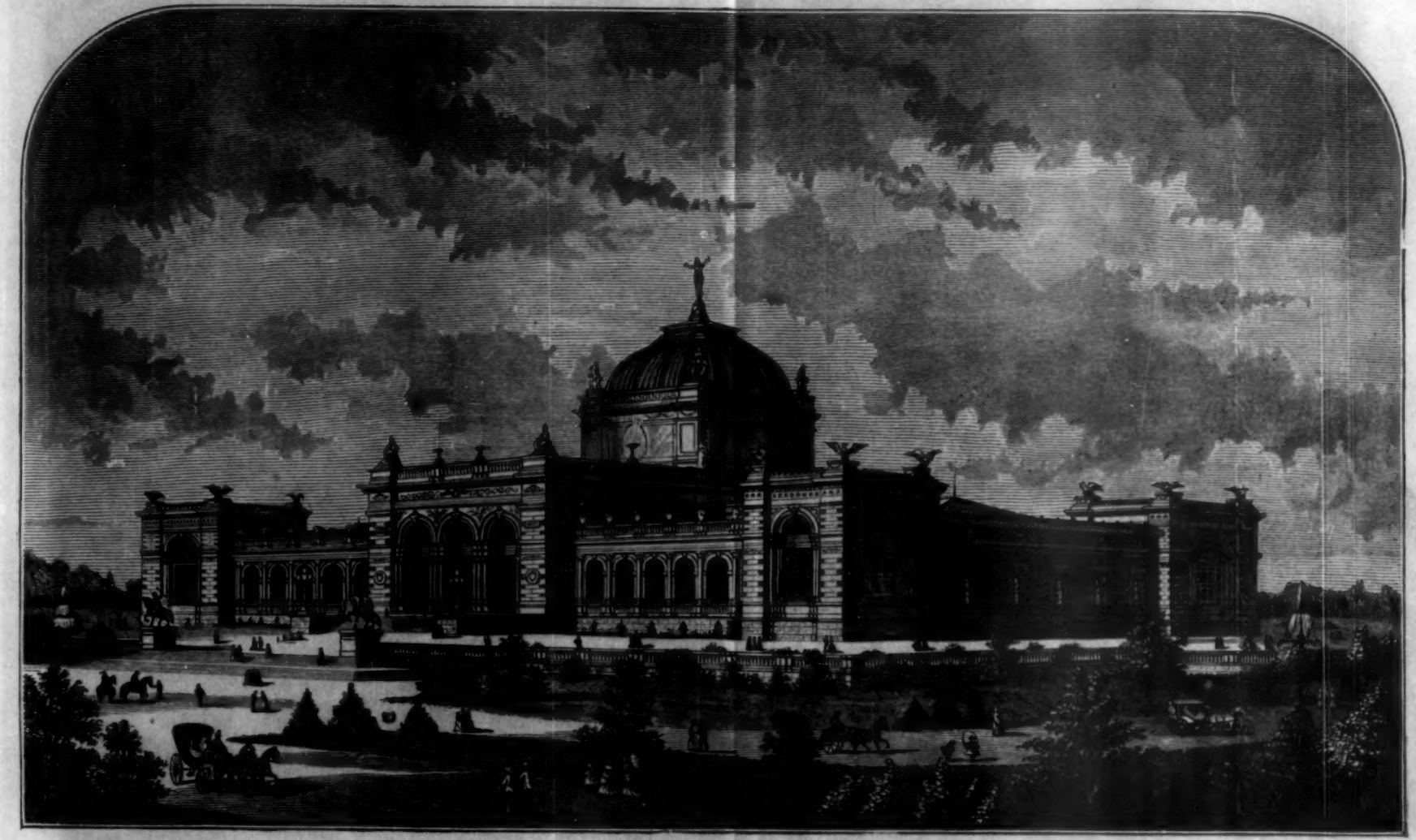
The main front looks southward; it displays three distinctive features:

1st. The central section, 95 feet long, 72 feet high, in which is the main entrance, 70 feet wide, consisting of three colossal arched doorways, 40 feet high and 15 feet wide, opening into a hall, and approached by a flight of thirteen steps. Between the arches of the doorways are clusters of columns terminating in emblematic designs illustrative of science and art. The doors, which are of iron, are relieved by bronze panels, having the coats-of-arms of all the States and Territories. In the centre of the main frieze is the United States coat-of-arms; the main cornice is surmounted by a balustrade with candelabras; and at either end is an allegorical figure representing science and art.

2d. A pavilion at each end, 45 feet long, 60 feet high, each displaying a window 30 feet high and 12 feet wide; it is also ornamented with tile work, wreaths of oak and laurel, 13 stars in the frieze, and a colossal eagle at each of its four corners.

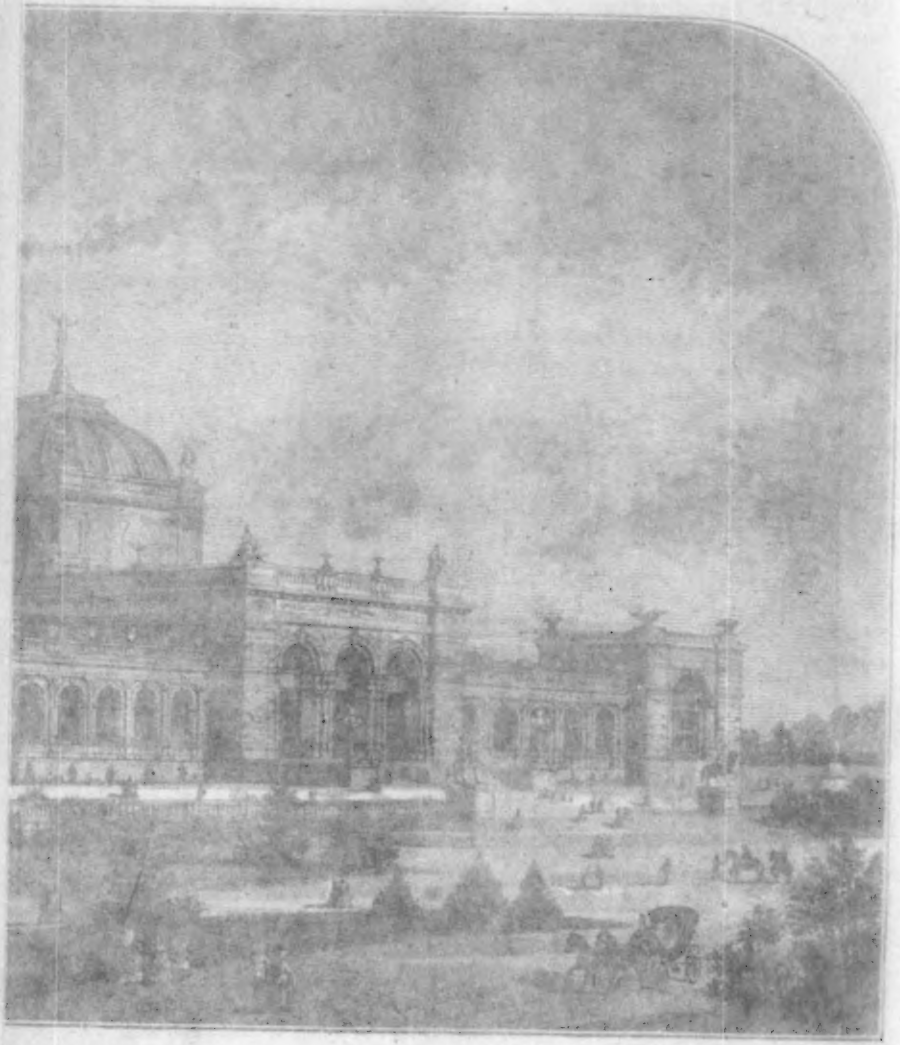
3d. Two arcades, each 90 feet long, 40 feet high, connecting the pavilions with the central section, and consist of five groined arches.

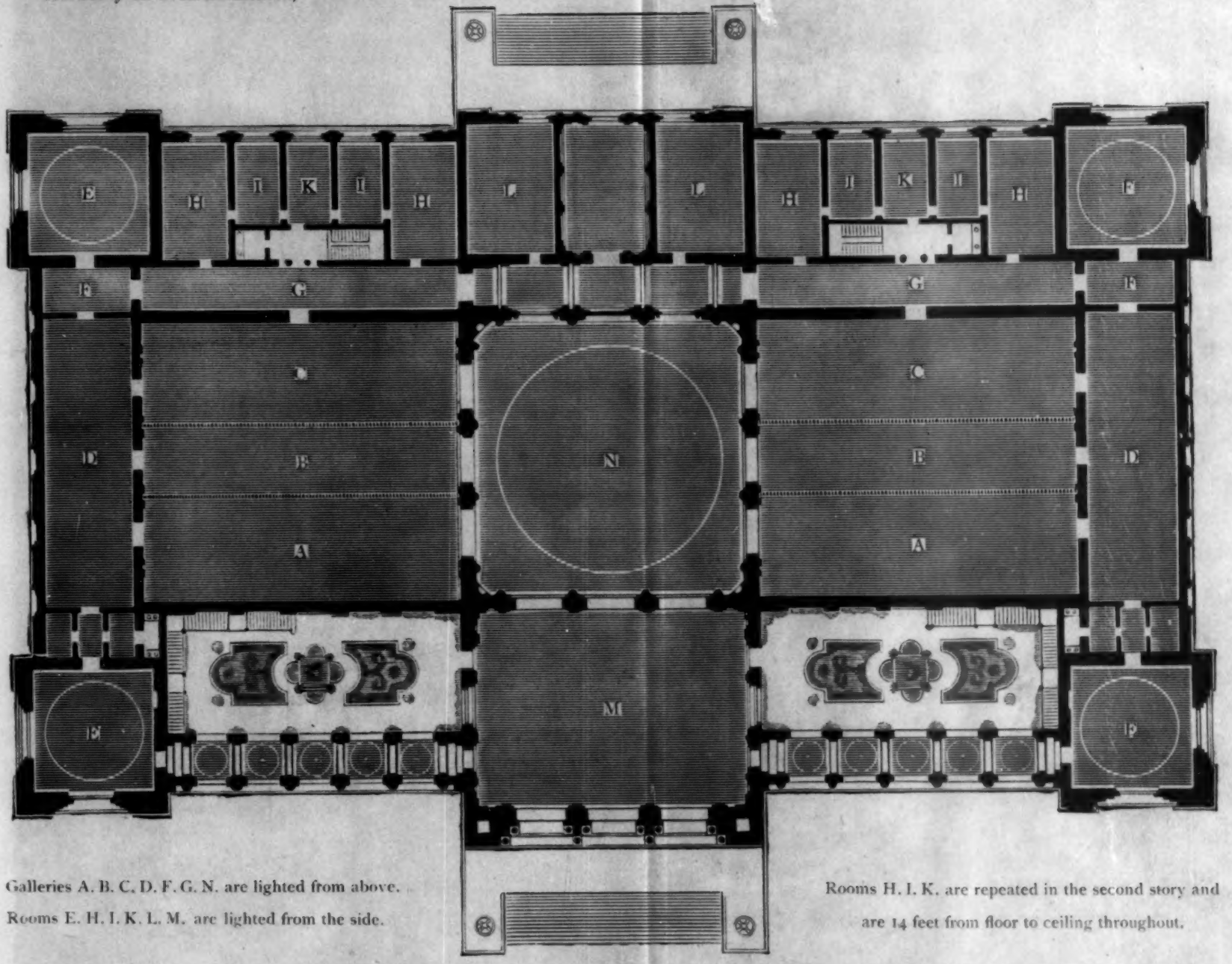
The arcades, a general feature in the old Roman villas but entirely novel here, are intended to screen the long walls of the gallery, and form promenades looking outward over the grounds and inward over open gardens, which extend back to the main wall of the building. These garden plats are each 90 feet long and 36 feet deep, ornamented in the centre with fountains, and designed for



ART GALLERY:

INTERNATIONAL EXHIBITION, PHILADELPHIA, 1876.





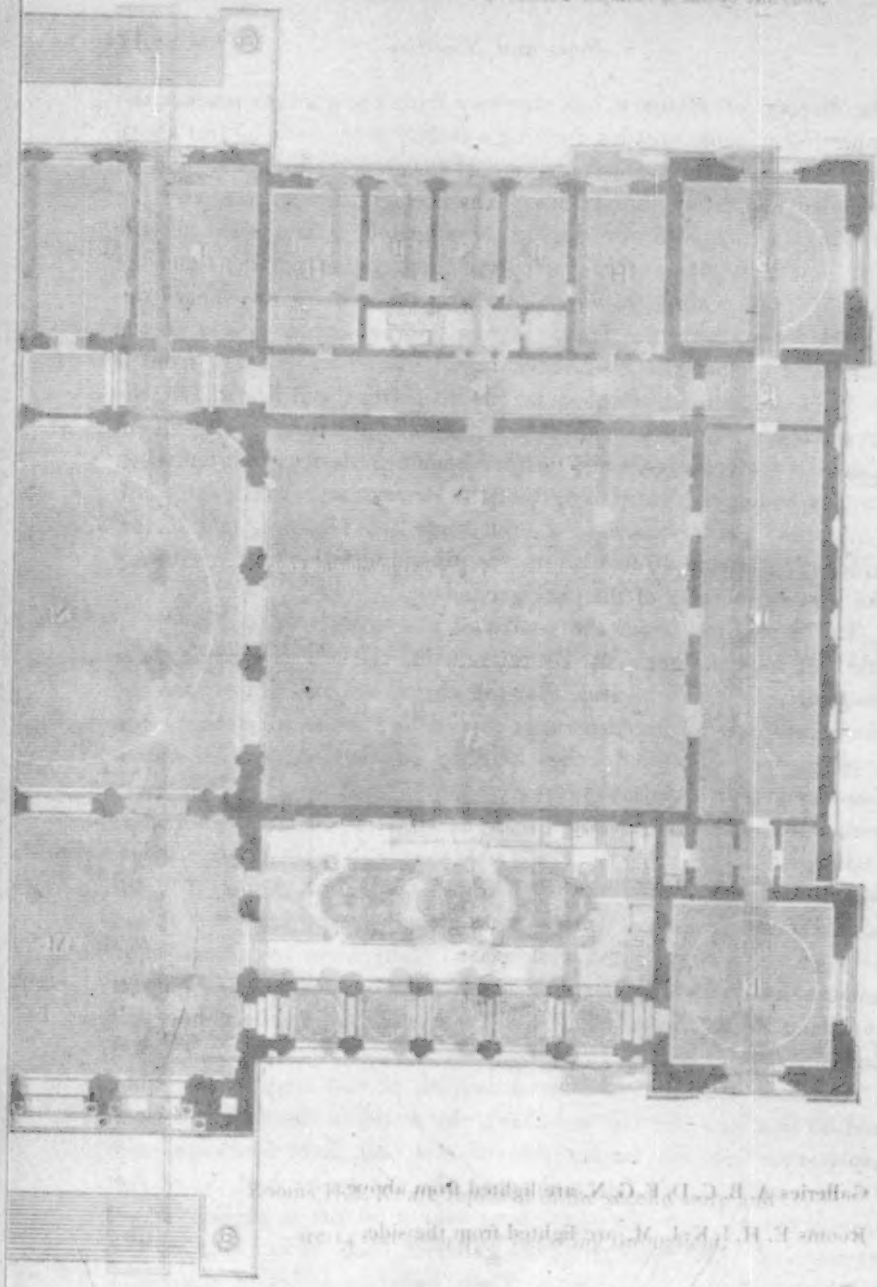
Galleries A. B. C. D. F. G. N. are lighted from above.

Rooms E. H. I. K. L. M. are lighted from the side.

Rooms H. I. K. are repeated in the second story and are 14 feet from floor to ceiling throughout.

GROUND PLAN OF THE ART GALLERY.

INTERNATIONAL EXHIBITION, PHILADELPHIA, 1876.



the display of statuary. A stairway from the gardens reaches the upper line of these arcades, forming a second promenade 35 feet above the ground. Its balustrade is ornamented with vases, and is designed ultimately for statues. The cornices, the atticas, and the crestings throughout are highly ornamented. The walls of the east and west sides of the structure display the pavilions and the walls of the picture galleries, and are relieved by five niches designed for statues, the frieze is richly ornamented—above it the central dome shows to great advantage. The rear or north front is of the same general character as the main front, but in place of the arcade is a series of arched windows, twelve in number, with an entrance in the centre; in all, thirteen openings above, in an unbroken line, extending the entire length of the structure; between the pavilions is the grand balcony—a promenade 275 feet long and 45 feet wide, and elevated 40 feet above the ground, overlooking northward the whole panorama of the park grounds.

The dome rises from the centre of the structure to the height of 150 feet from the ground. By reference to the diagrams of the dome construction, it will be seen that the entire weight of the dome and the figure-bases at its corners, is carried by four main wrought iron truss girders, 85 feet 8 inches long, by 16 feet deep, resting on the masonry at their ends and 8 feet from the walls, laterally. Iron beams with one end in the masonry cross and rest upon the main girders and extend inward until their ends meet the circle of the interior finish, which is 56 feet in diameter. On these beams, immediately over the main trusses, rise the elliptical truss girders of the dome, the spaces between them being filled with glass. The dome terminates in an immense bell which supports a colossal figure of Columbia. Figures typifying the four quarters of the globe stand at the corners of the dome.

The main entrance opens on a hall, M, 82 feet long, 60 feet wide, and 53 feet high (see Ground Plan), decorated in the modern renaissance style; on the farther side of this hall, three doorways, each 16 feet wide and 25 feet high, open into the centre hall, N, 83 feet square, the ceiling of the dome rising over it 80 feet in height. From its east and west sides extend the galleries, each 98 feet long, 84 feet wide, and 35 feet in height. These galleries admit of temporary divisions, A, B, C, for the more advantageous display of paintings.

The centre hall and galleries form one grand hall, 287 feet long and 85 feet wide, capable of holding eight thousand persons, nearly twice the dimensions of the largest hall in the country. From the two galleries, doorways open into two smaller galleries, D, 28 feet wide and 89 feet long. These open north and south into private apartments which connect with the pavilion rooms, E, forming two side galleries 210 feet long. Along the whole length of the north side of the main galleries and central hall extends a corridor 14 feet wide, which opens on its north line into a series of private rooms, thirteen in number, H, I, K, L, designed for studios and smaller exhibition rooms. All the galleries and central hall are lighted from above: the pavilions and studios are lighted from the sides. The pavilions and central hall are designed especially for exhibitions of sculpture.

The work on this building is well advanced, the main walls being all up, except a portion of the west end, and the greater portion of the cornice set; the principal portion of the roof is on and all the frame work of the dome is in place, and there seems no reason why it should not be completed by the 1st of January, next.

The frame work of the eastern half of the Main Exhibition Building is up and nearly all under roof, and the erection of the western half progressing very well.

Of Machinery Hall all of the eastern end is under roof and the glass sides are in, and the whole being painted; the frame of the western half all up and a large portion of the roof is on.

The iron and brick work of Horticultural Hall is up to the second story, and there is every prospect that it will be completed in the time specified in the contract.

One of the office buildings, at the intersection of Belmont and Elm Avenues, containing twenty-five office rooms, besides wash rooms, water closets, etc., is completed and now occupied.

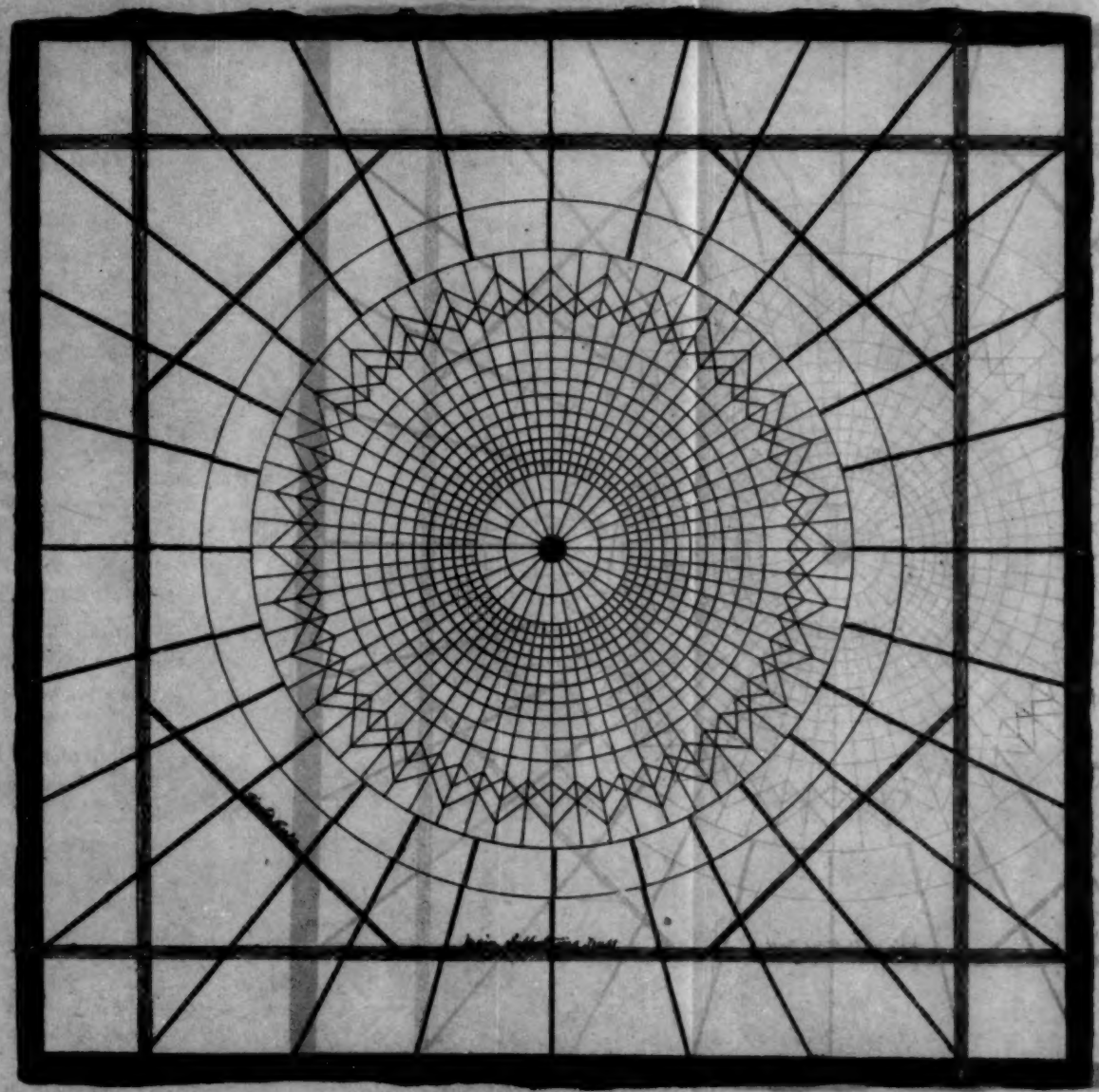
The drainage, water supply, grading and other preparations, are all being pushed forward with such energy as carries conviction that all will be in readiness in due time.

The interest in the Exhibition is constantly increasing in all parts of our own country as well as abroad. Thirty-five of the States and Territories having formed official advisory boards, most of which are actively at work, and the following nations have accepted the invitation of the President.

International Exhibition.
Philadelphia, 1876.

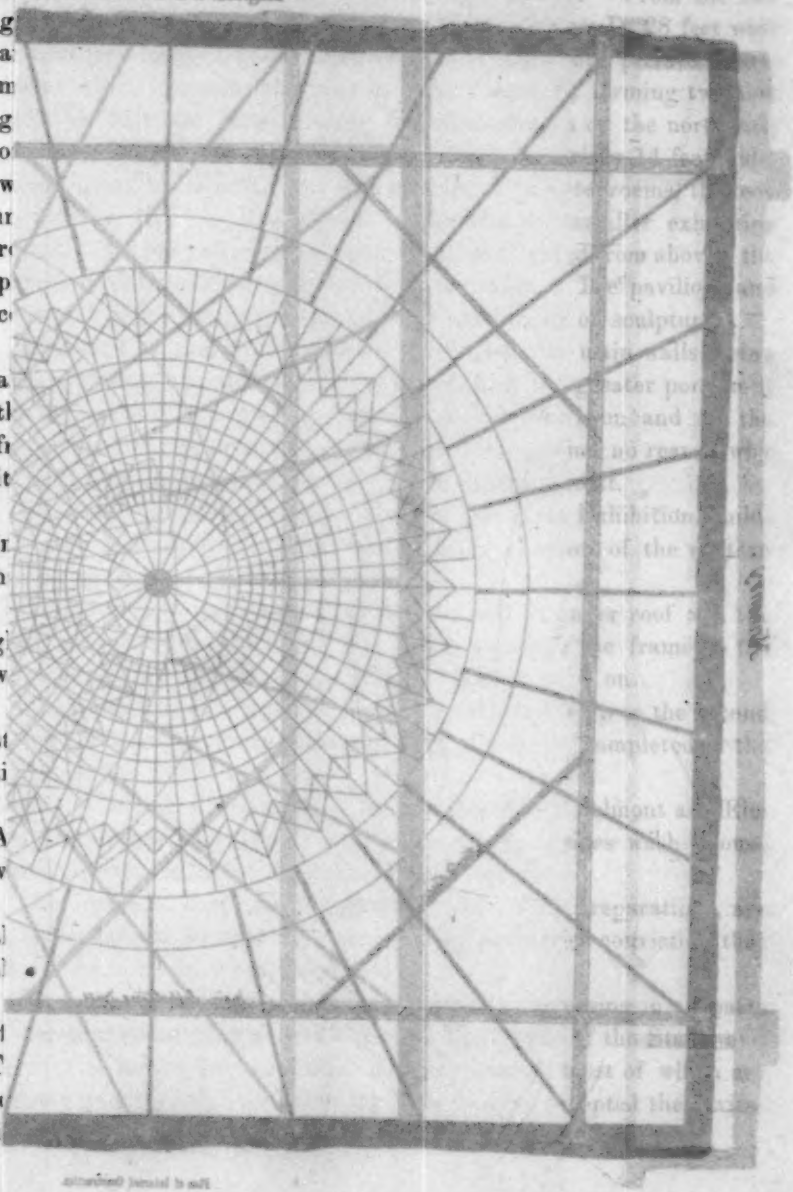
Art Gallery.
H. J. Thompson, Architect

Diagrams of Dome Construction.



Masonry.

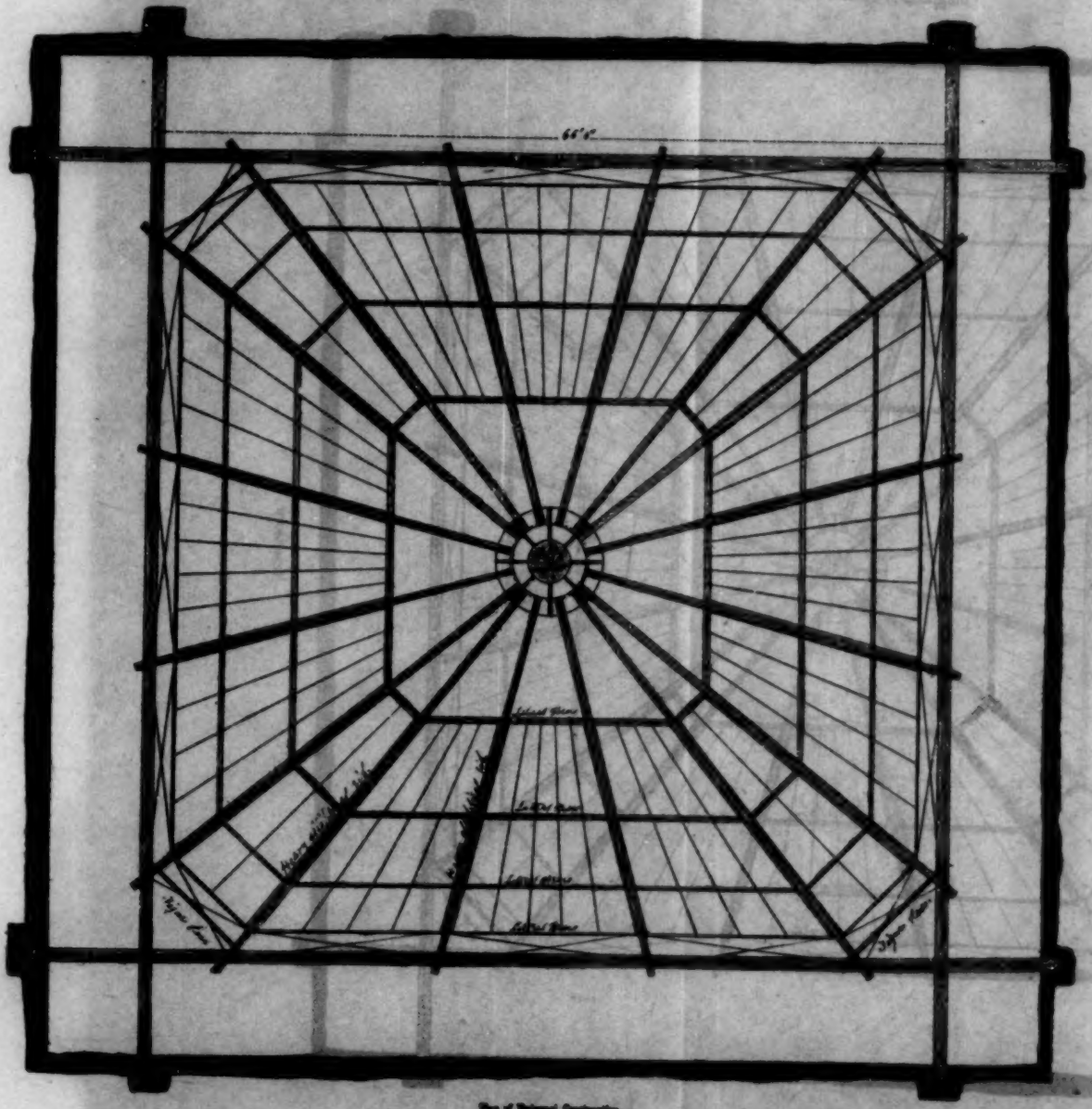
Plan of Internal Construction.



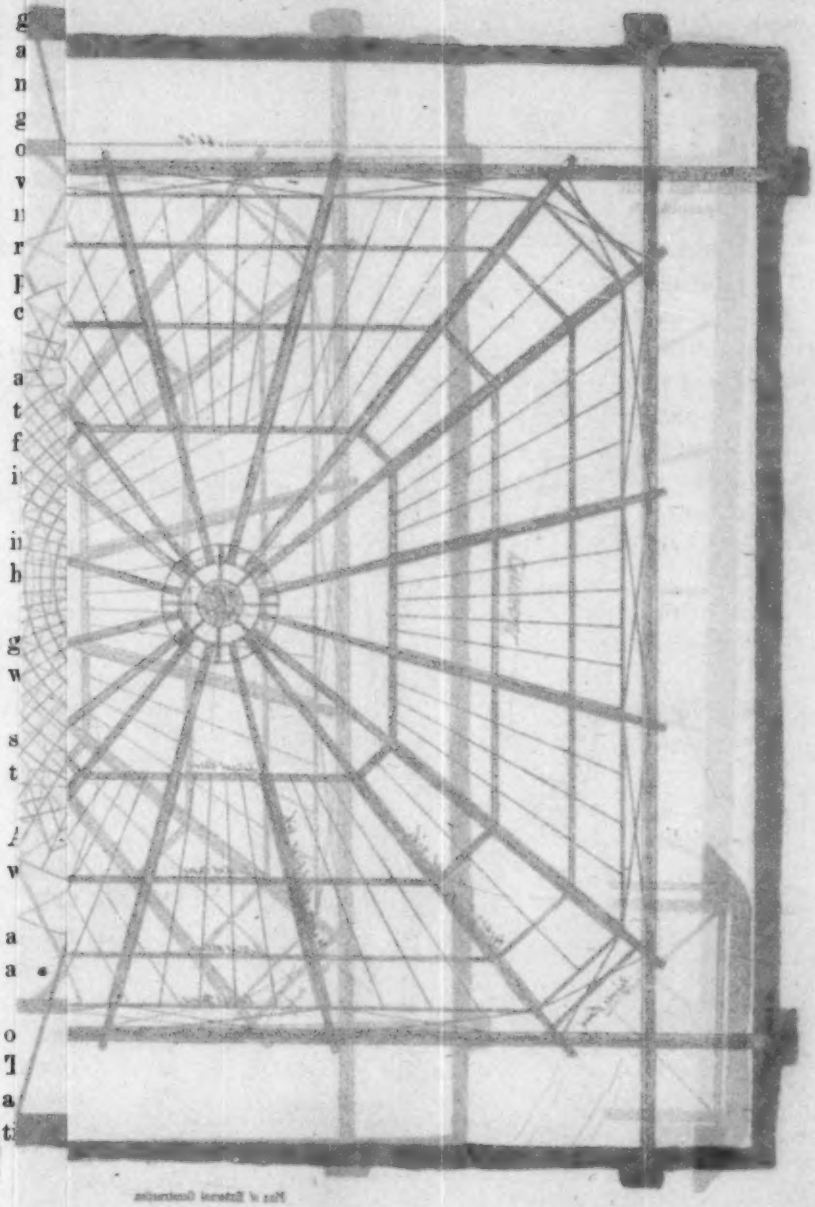
International Exhibition.
Philadelphia, 1876

Art Gallery.
H. J. Thompson, Architect

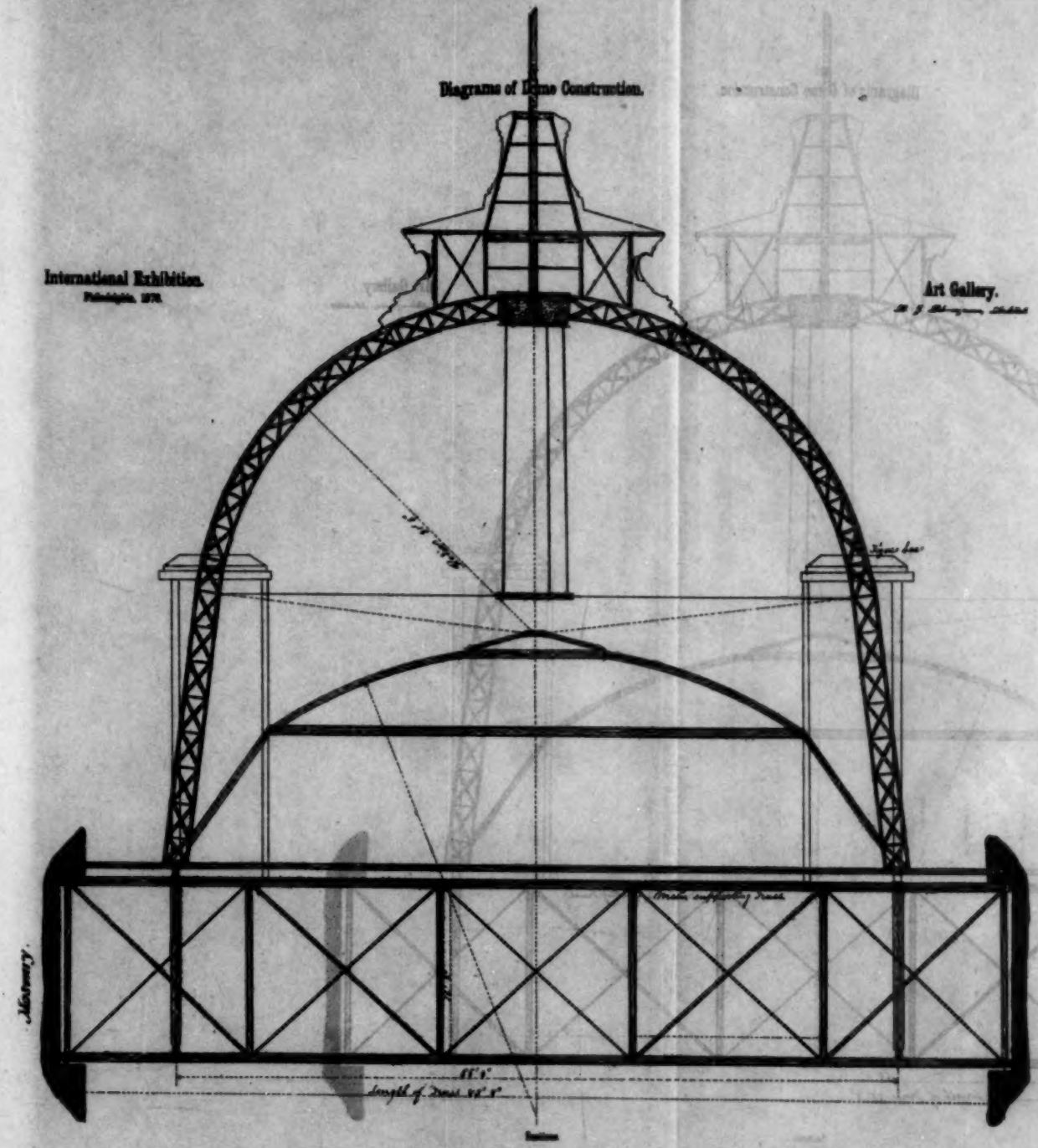
Diagrams of Dome Construction.

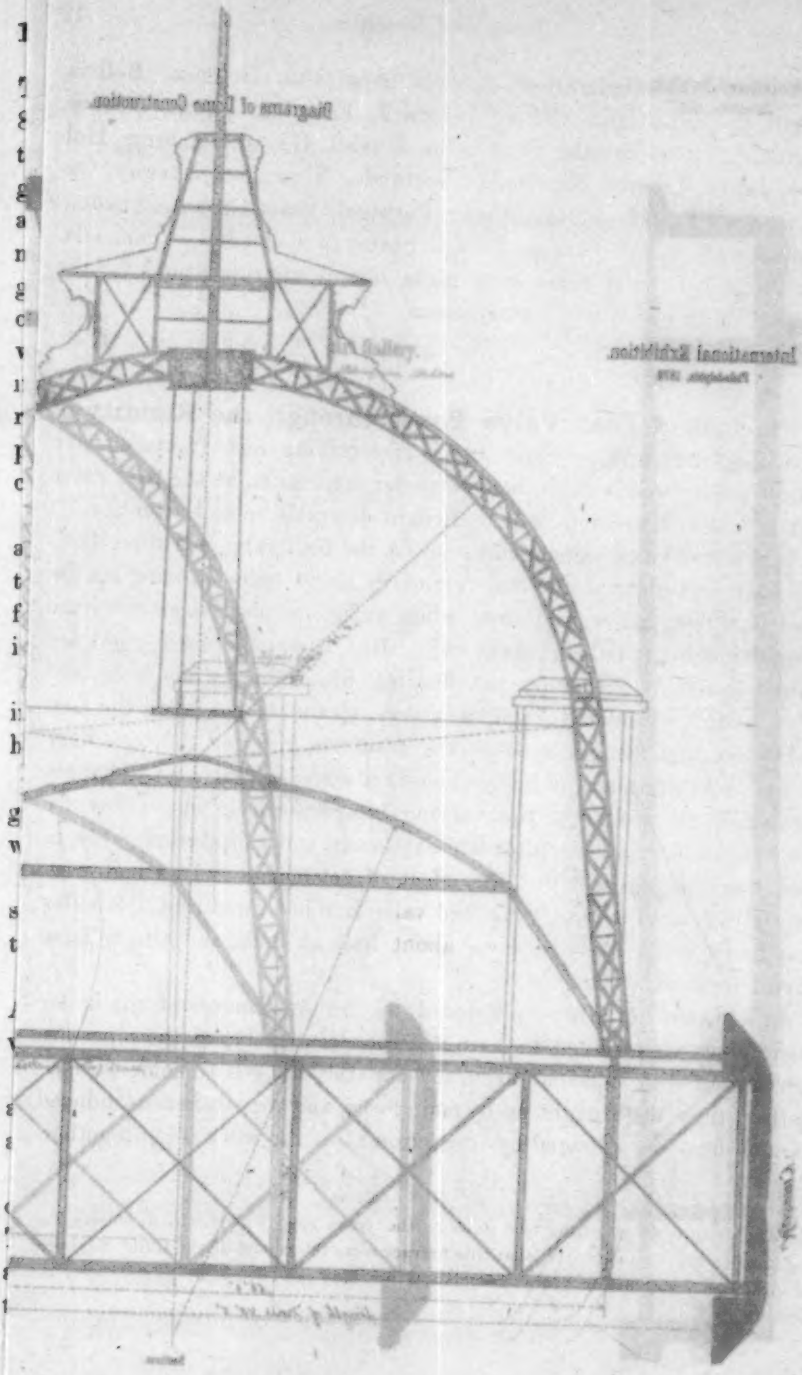


Plan of Diagonal Construction



Diagrams of Dome Construction.





Argentine Confederation, Austria, Australia, Belgium, Bolivia, Brazil, Canada, Chili, China, Denmark, Ecuador, Egypt, France, Germany, Great Britain, Guatemala, Hawaii, Hayti, Honduras, Holland, Japan, Liberia, Mexico, Netherlands, Nicaragua, Norway, Orange Free States, Persia, Peru, Portugal, Siam, Spain, Sweden, Switzerland, Tunis, Turkey, United States of Colombia, Venezuela.

A large portion of these have made liberal appropriations for the support of governmental commissions.

K.

Fracture of Feed Valve Boxes through the Rigidity of the Connections.*—Some cases of straining and fracture have recently been met with, in boilers under inspection, at the feed valve boxes, and to these defects it is thought desirable to call attention.

It is a convenient arrangement to fix the feed valve box directly to the front end plate of the boiler, and in many cases to bring up the feed pipe from below, and this, when sufficient play is given to the connections, is found to work well. But when the feed pipes are bound so tightly, either by the flooring plates or by the main feed pipe, as to be rendered rigid, a severe strain is put upon the feed valve box, and from this cause the fractures referred to above have arisen. Attachments to boilers should always be elastic, as all boilers move more or less from the varying temperature to which they are subjected which induces alternate expansion and contraction, while to this in some cases is added the effect of settlement. In a boiler recently examined in which the feed valve box had fractured, the boiler was found to have settled down about half an inch, and also to have thrust forward.

In addition to the strain induced by the movements of the boiler some pipes are strained in fixing. Too frequently, if the pipes are not set out with sufficient accuracy for the flanges to come well together, they are brought up by main force, and the strain thus induced cannot easily be detected by inspection after the work is put together.

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*The practice of attaching feed pipes to the front head of cylindrical boilers is so common in the United States, that this extract from the report of the Chief Engineer of the Manchester Steam Users' Association for May and June, 1875, will be of interest.

In one range of boilers, the joint was found to spring open three-eighths of an inch on the bolts being withdrawn, showing how much force had been used in bringing the parts together, while, in another case, one of the feed valve boxes of a pair of new boilers broke through the root shortly after they had been set to work.

To prevent these fractures, it is recommended that the opening in the flooring plates through which the stand pipes pass, should be made large enough to afford ample room for play. Sometimes these pipes have been found so bound by the plates that as much as three-eighths of an inch has had to be cut away around them before they were fully relieved. In some arrangements a flange, cast upon the stand pipe as a base, rests on the floor plates and thus resists the movement of the pipe. In others, loose collars are introduced which cover the opening in the floor plates around the stand pipe, and make a neat finish, while at the same time they admit of free movement. The loose collar is much to be preferred and it is recommended that all those flanges that bear upon the flooring plates be chipped off.

Further, to prevent the stand pipe being bound fast by the main feed pipe, the connection between the two should be such as to admit of movement, and may be made by a wrought iron horse shoe shaped pipe or by a copper pipe either in the shape of a round elbow, or of a "swan neck," as may be applicable; while other arrangements for the same purpose will no doubt suggest themselves as required. The horse-shoe shaped pipe was introduced by the manager of a large mill, the boilers at which are under inspection, and has been found to give great satisfaction. When this elastic connection is introduced, the main feed pipe may safely be laid on the solid brickwork at the bottom of the pit beneath the flooring plates, but without this elastic connection, the plan of bedding the main feed pipe on the solid, throws a heavy strain upon the feed valve box when any downward movement of the boiler takes place.

It may be added that blocks are sometimes found wedged in beneath the blow-out elbow pipe, thus forming a solid abutment, which entirely frustrates the object of the recess in the front cross wall around this pipe, and, in the event of any settlement of the boiler, would inevitably induce a considerable strain.

The members are requested to instruct their mechanics to examine the connections to their boilers and where necessary, to have the

arrangements corrected in accordance with the recommendations given above.

It is very desirable that the inspectors should frequently examine the feed and blow out pipes in the hearth pit, and this they are prepared to do, but have sometimes hesitated to give the firemen the trouble of raising the flooring plates. The members will see, however, the importance of having these pipes examined, and it would assist in the accomplishment of this if they would be good enough to give their boiler attendants the necessary instructions.

L. E. FLETCHER,
Chief Engineer.

OFFICE—41 *Corporation Street, Manchester.*

The Phonometer. — One of the most fruitful sources of collision in navigation is foggy weather; a murky atmosphere is often the cause of far greater anxiety to the mariner than are reefs, icebergs, and many other dangers of the deep. The present system of fog signalling at sea removes those in command of ships but one degree from the utter state of helplessness in which its introduction found them. It consists simply in one ship announcing to another, by steam whistle, fog horn, or other means, that she is somewhere in her vicinity; but as to what her course is, nothing can possibly be known, so that each can only slacken her speed and steer in an imaginary right course, which has but too often proved a really wrong one. Nor are the perplexities of the position diminished, but sadly increased, by the unseen presence of a third or even a fourth vessel, and it will never be known how many ships have gone down with all hands during fogs. Survivors there are now and then to tell of these disasters, but they are few and far between, and it is not too much to assume that of our missing ships a very large number have been cut down in a fog. The anxious experiences of Captain R. E. Harris, during many dense fogs, led him to attempt the solution of the problem of comparative safety for vessels under such conditions. He knew that at night, in clear weather, his ship's course was made known to others, and the course of others to him by visible means, and it occurred to him that he might so improve the audible means he had at command for rendering the presence of his ship known in a fog as to make her course known also. This idea he has worked out to a practical end, embodying it in an

instrument to which he has given the name of the Phonometer. By means of this invention the officer in command of a steamer can make known in which quadrant of the compass he is steering, navigation being thus greatly facilitated, and the risk of accident reduced to a minimum, either in narrow waters or in the open sea. The apparatus consists of the mechanism of a clock placed in a horizontal position under a special dial. The seconds are arranged near the outer circumference of the dial, which is about 8 inches in diameter, while the hour and minute dial is about 2 inches in diameter, and is placed on the lower part where the seconds dial of a watch is usually sunk. There are four seconds' hands placed at right angles to each other and radiating from the centre of the main dial. Outside the seconds' circle are marked five black segments with intervals between them. One segment measures ten seconds in length and the other four five seconds each, with intervals of three seconds. Outside the glass which protects the dial and pivoted at its centre is a brass segment plate so arranged as to obscure those segments on the dial not required for immediate use, and thus to prevent error in signalling. Around the dial and outside it, is a flat ring of metal about 2 in. broad on which all the points of the compass are marked. The apparatus is placed on a stand with the upper part of the dial towards the head of the ship, the stand being fixed on the bridge just by the steam-whistle so that both are under the direct control of the officer in command. In using the phonometer the compass-ring, or dumb-card, as Captain Harris termed it, which is a very important feature of the instrument, is moved round until the true points on which the ship is sailing is in a line with the ship's head, all the true points of the horizon being thus indicated. These points being accurately known, it follows that all steamers in each other's vicinity, fitted with the phonometer, will have the true quadrants of the compass distinctly and concordantly represented. The steam-whistle or fog-horn is the important adjunct of the phonometer, and it is the duration of each whistle or blast and their number that indicates the course of a ship. The black segment covering ten seconds of space is a measure of ten seconds of time, the other segments indicating periods of different duration, and a whistle of ten seconds' duration indicates that a vessel is steering within the quadrant from N. to E. $\frac{1}{4}$ N. Assuming this to be the course of the vessel, the brass-covering segment would exclude all the other black segments, and the officer would wait until one of the four

seconds' hands entered that segment. He would start the whistle and hold it on during the time the hand traversed that segment. This operation must be repeated at intervals during the continuance of the fog. Another ship coming within sound would at once know the course of the first, and would indicate her tack in like manner. Following out Captain Harris's code, two blasts, each of five seconds duration, with an interval of three seconds, represents from E. to S. ¼ E. Three blasts of similar duration and intervals represent from S. to W. ¼ S., while four blasts of the same length and spaces indicates from W. to N. ¼ W. The special object of the four seconds' hands is to enable the operator to reply readily to the signals from other ships, which could not be done if the revolution of a single hand had to be waited for. By the peculiar construction of the dial the necessity of counting the seconds when signaling is entirely obviated. The apparatus having been designed by a sailor, and being based upon nautical data, commends itself at once to the nautical mind, presenting no new theory, but being engrafted on ordinary practice. An inspection of its working has led us to the conclusion that, subject to such slight codal modifications as practice might suggest, it presents the true solution of the problem of safe navigation in foggy weather.—*The Times.* (London.)

Notice.—By the Committee on Publication.—Prof. Geo. F. Barker having resigned the editorship of this Journal, the present number is issued by the committee on publication under some disadvantage.

Until the appointment of an editor the Journal will be issued by the committee under the superintendence of Mr. J. B. Knight, Secretary of the Institute, to whom all communications intended for the Journal should be addressed.

The interruption to regularity of issue, caused by the resignation of the former editor, the committee will endeavor to rectify, and after the August number, [which will be subject to some detention] they hope to present the JOURNAL with regularity to its readers.

The Committee ask from the members and friends of the Franklin Institute their cordial support to the JOURNAL. Contributions of original matter suitable for its pages will be received by Mr. Knight, for the committee.

Bibliographical Notices.

NOTES IN BUILDING CONSTRUCTION. Part I. *Published by Rivingtons. London, Oxford and Cambridge*, 1875.—This work, of which the first part, or elementary course only, has yet appeared, and for sale by J. B. Lippincott & Co., has been arranged to meet the requirements of the syllabus of the science and art department of the committee of council on education at South Kensington, London, and is intended for the use of students preparing for examination in building construction. It is a work, however, that strongly commends itself to any one interested in this specialty, and especially to those about entering an architect's office to study the profession.

It treats of those matters of which he preliminarily knows very little—and finds the necessity of knowledge daily, to wit, the practical details of his business. The information is worked up in very readable shape, being collected in as condensed a form as practicable, very largely from first-class authorities, perhaps not accessible to the student, or at least difficult to cull from if attainable. The book is hardly as "American" in style as we could wish, some such matters as, for instance, roof details, the joints and connections, etc., not being always of the most improved modern designs or according to the best practice in this country. Some of the formulæ also are not the best, nor according to the latest authorities. Still, however, those who are in search of information on the subject treated will find the work of great use and containing very much that is important and valuable. We hope soon to see the second and third parts of the work.

W.

THE REPORT OF THE TWENTY-SEVENTH EXHIBITION, held by the Franklin Institute, is now published and ready for distribution among the members. It makes a volume of 284 pages, and is a full history of the Exhibition from its first inception; including a catalogue of Exhibitors and full reports of the Judges in the various classes. There is also a plan showing the arrangement of the aisles and passages. The Treasurer's statement of the total receipts and expenditures, shows a profit of $52,371.37.

While its financial success must be very gratifying to every member, it is but one of the benefits which have been derived from the Exhibition. The large accession of new members, there having been four hundred and forty-two,—an increase of three hundred and eighty-two over the previous year—and the renewed interest among the old members can scarcely be measured in money, and must prove of great and lasting benefit to the Institute.

Civil and Mechanical Engineering.

JONVAL TURBINES, AND PLUNGER AND BUCKET PUMPS.

By Emile Geyelin.

Dynamometrical tests made on a Jonval Turbine, working under high pressure; also, measurements of actual delivery of water from two sets of pumps propelled by said Turbine, constructed for the city of Manchester, N. H., by the Geyelin department of the firm of R. D. Wood & Co., Philadelphia.

GENERAL DESCRIPTION.

These works are located at the mouth of Lake Massabesic, and comprise a fall of water of forty-five feet, which is led to a pumping station, from whence the water, to the extent of five hundred cubic feet per minute, is forced into a reservoir through an ascending main, twenty inches in diameter and seven thousand feet in length. The actual lift does not exceed, in ordinary condition, sixty-two pounds to the square inch; but all parts are constructed to resist a pressure of two hundred pounds to the square inch, the pumping works being so constructed as to force the water directly into the distributing main when desired. These works, including dam, water ways, and general design at the pumping station, were planned and directed by J. T. Fanning, H. E.; the Turbines and machinery proper were placed by E. Geyelin.

DESCRIPTION OF TURBINES AND PUMPS.

Two Turbines of one hundred and twenty-eight horse-power, each thirty-four and a half inches in diameter, receive the water from a chamber placed at the bottom of the fall, on top of which chamber is a stand pipe, that is to receive the recoil in case of a sudden closing of valves. The motions of these Turbines are independent of each other, and can be transmitted to either of two sets of pumps, by means of shifting gears.

TESTS MADE AT THE MANCHESTER WATER WORKS, JUNE, 1875, TABLE NO. 1.—WHEEL TESTS.

Number of Experiment.	Temperature of Water.	Time of commencing Test.	Time of closing Test.	Duration of Test in seconds.	Total number of revolutions [of wheel during Test.	Number of Revolutions of wheel per second.	Number of Revolutions of wheel per minute.	Weight on scale in pounds.	Effect in feet pounds per second.	Head of water on wheel in feet and decimals of a foot.	Height of back water.	Acting head of water on wheel in feet and decimals of a foot.	Height of *Weir* Water going over a weir 8 ft. wide from both wheels.	Height of water going over a weir 8 feet wide from 1 wheel.	Double feet of water discharged per second less total waste.	Effect of same in feet pounds per second.	Ratio of effect of wheel.	Double feet discharged per second less ¼ of the waste.	Effect of same in feet pounds per second.	Ratio of effect of wheel.	Velocity of centre of bucket of wheel in feet per second.	Ratio of velocity of centre of bucket and theoretical velocity of water	Horse power of wheel by Test, if increased to 45 feet head.	Double feet of Water discharged in a second under 45 feet head.
	Degrees	June 23, 1875. H.M.S.	H.M.S.									Feet.	Feet.											
1	60	4 20 06	4 21 48	102	500	4·902	294·	250	61·275	44·04	1·85	42·19	·204	1·112	27·969	73,539	·8333	29 190	76·697	·7959	37·54	·7206	129·75	31·134
2	60	June 24, 1875. 10 34 03	10 35 13	70	300	4·2857	256·6	280	59·999	44·29	1·85	42·44	·204	1·113	29·0097	74,035	·8104	29·2357	77·259	·7766	32·82	·6262	122·65	30·993
3	60	10 51 26	10 54 40	194	500	2·5773	154·6	400	51·546	44·29	1·78	42·51	·204	1·113	29·0097	74,157	·6897	29·2307	77·387	·6651	19·73	·3773	106·75	30·942
4	60	1 08 56	1 11 14	138	500	3·6232	217·39	330	59·7828	44·21	1·85	42·36	·204	1·110	27·8802	73,679	·8125	29·1101	76·794	·7784	27·75	·5315	122·60	30·924
5	60	1 17 49	1 19 50	121	500	4·1322	248·	300	61·983	44·21	1·83	42·38	·204	1·110	27·8802	73,613	·8420	29·1101	76·854	·7768	27·75	·4859	117·88	30·924
6	60	1 22 13	1 24 43	150	500	3·3333	200·	350	67·333	44·21	1·83	42·38	·204	1·110	27·8802	73,613	·8121	29·1101	76·854	·7761	27·24	·5314	122·61	30·924
7	60	1 24 51	1 27 09	138	500	3·6232	217·39	330	59·783	44·21	1·83	42·38	·204	1·110	27·8802	73,613	·8324	29 1101	76·854	·7975	27·82	·7206	125·67	30·924
8	60	1 55 17	1 56 59	102	500	4·9020	294·	290	61·275	44·21	1·83	42·38	·204	1·110	27·8802	73,613	·8159	29·1101	76·834	·8057	36·47	·6986	119·96	30·924
9	60	1 57 20	1 59 05	105	500	4·7619	285·71	290	61·905	44·21	1·83	42·38	·204	1·110	27·8802	73,613	·8490	29·1101	76·824	·8134	35·45	·6791	128·17	30·924
10	60	1 59 23	2 01 13	108	500	4·6296	277·8	270	62·499	44·21	1·83	42·38	·204	1·110	27·8802	73,613	·8490	29·1101	76·824	·8134	35·45	·6791	128·17	30·924
11	60	2 01 25	2 03 15	112	500	4·4643	267·8	280	62·500	44·21	1·83	42·38	·204	1·110	27·8802	73,613	·8490	29·1101	76·854	·8134	34·19	·6549	123·17	30·924

Friction Pulley = 42 inches Diameter, 10½ inches Face.
Weight = 1593 pounds, about equal to usual shaft and gear.
Weight of Brake = 1023 pounds, balanced off.

SAMUEL WEBBER.

TESTS MADE AT THE MANCHESTER WATER WORKS, JUNE, 1875, EFFECT OF PUMPS, TABLE NO. 2.—WATER DELIVERED AT RESERVOIR.

Number of Experiment.	Number of wheels used.	Experiment commenced.	Experiment ended.	Duration of experiment expressed in minutes.	Number of Revolutions of wheel per minute.	Number of strokes of pump per minute.	Actual head of water on wheel in feet.	Height of flow of water over a weir 8 feet wide.	Height of flow of water over a weir 8 feet wide, while one of the wheels was running.	Cubic feet of water discharged through wheel per minute, less ¼ waste.	Effect of same expressed in feet pounds per minute	Height to which the water was pumped.	Height of flow over a weir 5 feet wide, stationed at delivery in reservoir.	Cubic feet delivered per second.	Number of gallons delivered in 24 hours.	Weight lifted, expressed in feet pounds.	Weight due friction in pipe.	Total effect expressed in foot pounds.	Ratio of effect to power used.	Velocity of water in main, in feet per second.	Water used, to water delivered in reservoir.
		H. Min. June 25,	H. Min. June 26,																		
1	1	10 52	11 06	14	107·16	15	42.33	·203	1·1280	29·794	78,547	110·55	0·391	4·007	2,590,004	25,528	12,07	28735	·3658	1·8368	7·448
		June 26,																			
2	1	10 01	10 20	19	135·74	19	42·80	·203	1·1690	31·466	83,873	110·59	0·453	4·9845	3,221,573	34,303	23,12	36615	·4365	2·2847	6·313
3	2	10 49	11 03	14	178·60	25	42·38	·203	1·5740	50·536	133,380	110·62	0·502	6·8573	4,431,989	47,191	54,58	101649	·3947	3·1431	7·369
4	2	11 11	11 34	23	214·32	30	42·28	·203	1·6590	54·564	143,684	110·66	0·629	8·007	5,233,228	55,793	80,61	63784	·4439	3 7113	6·241
5	1	12 40	4 40	240	142·88	20	44·858	·203	out	31·466	87,960	110·58	0·475	5·3469	3,455,817	36,731	25,28	39259	·4466	2·4508	6·

Water used to lubricate steps = 10·8966 cubic feet per minute = 4890·34 gallons per hour.
Revolutions of wheel to 1 stroke of pump = 7·144.
Number of strokes of pump attained by 1 wheel = 20·66.

SAMUEL WEBBER.

Water pumped by calculation = 648242 gallons.
Water pumped by weir and lubricator = 595,529·86 gallons.
Water pumped by measure reservoir = 508,336·65 ga lons.
Water as shown by weir in reservoir = 575,969·50 gallons.

The gears are bevel and spur (mortise) and so proportioned as to give twenty-eight strokes to the pumps a minute, while the Turbine makes two hundred and twenty revolutions per miunte. The pumps are four in number and are placed in a vertical position. Diameter of plunger, eleven and a quarter inches; length of stroke, forty inches. The receiving valves are in each of the four pumps of the kind known as "Double Beat Cornish" and are seven in number in each set. The air vessels, placed at the junction of two pumps, are supplied with air by means of automatic pumps.

DESCRIPTION OF THE TESTS.

Two tests were made and conducted by Samuel Webber, H. E., of Manchester, who used the dynamometer and water guage, that served in the experiments made at Lowell, by J. Francis. The table No. 1, gives the results under different velocities, varying from 294 to 217 revolutions per minute, wherein the percentage of useful effect, varied only from 0·7989 to 0·7781. As shown, the best results were obtained at velocities of 270 to 280 revolutions per minute, amounting to 0·8134.

The duty of the pumps is given in table No. 2, the results therein stated were obtained by the measurement of the depth of water flowing over a weir, put up at the reservoir; width of weir, sixty inches. From the data obtained, the actual duty of the pumps is at thirty strokes, equal to eighty-eight per cent. of the theoretical capacity of the pumps. When the length of the ascending main (7000 feet) is taken into consideration and a probable leakage, these results are fair, though with a short and tight main, the duty should not be less than ninety-four per cent.

Export of the manufactures of Iron from Philadelphia.—During the fiscal year ending June 30th, proximo, Philadelphia exported to foreign countries the following iron products, aggregating $1,001,387. Railroad bars, $9,977; car-wheels, $64,900; machinery, $767,560; nails, $15,030; other manufactures of iron, $143,920.

The total exports of the city during the same time were $28,588,019.

REVIEW OF NAVAL CONSTRUCTOR WILSON'S EXPERIMENT FOR ASCERTAINING THE CENTRE OF GRAVITY OF THE U. S. STEAMER "SHAWMUT."

By Chief Engineer B. F. Isherwood, U. S. Navy.

Having occasion to consult the 58th volume of this Journal, my eye was arrested on page 97 of the number for August, 1874, by an article headed *Experimental Determination of the Centre of Gravity of the United States Steamer "Shawmut" by T. D. Wilson, Naval Constructor, U. S. N.* As this steamer was one of a class of large screw gun-boats for which I designed the machinery in 1863, and whose elements and performance I obtained with the greatest exactness, I read the article with interest in the expectation of finding the subject properly handled, and my knowledge of the qualities of those fine vessels increased. Great, therefore, was my disappointment, when in place of a carefully executed experiment under proper conditions, and an accurately calculated result from correct data, I found mainly errors of fact, procedure and deduction. Now, inasmuch as sagacious experiments of this kind are of the highest value in furnishing science with its indispensable data, so fallacious ones, being correspondingly injurious, should have their faults promptly exposed to prevent the serious mistakes that would follow their acceptance; and, as I am known to possess the true data in this case, I am not willing to sanction, by my silence, the propagation of errors I am able to correct.

The experimental method of determining the position of the centre of gravity of a ship, was completely set forth by Bouguer, more than one hundred and twenty years ago, as is well known to all persons educated in this and kindred subjects. To the dead Bouguer, therefore, is due the credit of the investigation and not, as the reader is left to infer from the remarks of Mr. Wilson, to the living Mr. Barnaby, whose demonstration has been textually copied word for word. The method, in fact, is neither new nor unknown, nor is there any difficulty in its application.

For the proper understanding of an experiment of any kind, the scale on which it was tried must be known, or the size of the object experimented on, which in this case would be defined by the dimen-

sions of the "Shawmut." As Mr. Wilson—apparently unaware of this necessity—has not stated these dimensions, I now give them in supply of his omission.

Length on mean load-line from forward side of rabbet of stem to after side of sternpost, . .	179·5	feet.
Extreme breadth, ...	30·0	feet.
Mean load-line above the lower edge of the rabbet of the keel, ...	9·33	feet.
Lowest port-sill above the mean load line, . .	5·5	feet.
Displacement to the mean load-line, . .	29216 0	cu. ft.
Area of mean load-line, ...	4196 0	sq. ft.
Area of the greatest immersed transverse section,	240·4	sq. ft.
Centre of displacement before the middle of the length,	0·2	foot.
Centre of displacement below the mean load-line,	3·87	feet.
Latitudinal meta centre above the centre of displacement, ...	8·53	feet.
Ratio of displacement to circumscribing parallelopipedon,	0·5813.	
Ratio of load-line to circumscribing parallelogram,	0·779	
Ratio of greatest immersed transverse section to circumscribing parallelogram, ...	0·858	
Area of the ten principal sails. (Courses, topsails, topgallant sails, jib and spanker.) . . .	9199	sq. ft.
Centre of effort of the sails before the middle of the length of the mean load-line, . . .	6·56	feet.
Centre of effort of the sails above the mean load-line,	45·92	feet.
Ratio of forward moment to after moment, .	1·00 to 0·75.	

In December, 1866, the "Shawmut" having on board all she could stow, including one hundred and sixty tons of coal, one hundred and eighteen men, bread for forty days, other provisions for sixty days, and water in tanks for eight days, was officially reported as having a mean draught of water of 10 feet above the lower edge of the rabbet of the keel, at which draught her displacement of sea-water is 917·8 tons. Now Mr. Wilson states that during his experiment her draught of water was 11 feet forward and 13 feet 6 inches aft above the bottom of the keel, corresponding to a mean draught of 10 feet 7 inches above the lower edge of its rabbet. As his experiment was made at Washington, this draught was in fresh water, but even after correction for sea-water it is still about 4 and 6-10ths inches more than

the reported deep load draught of the vessel in 1866. The exact displacement of the vessel at 10 feet 7 inches mean draught above the lower edge of the rabbet of the keel, is 965·4 tons in fresh water instead of the 1010 84 tons stated by Mr. Wilson. Further, I find the centre of displacement or buoyancy at that draught of water is 4·42 feet below the mean load line. Also, the meta centre is 7·56 feet above the centre of displacement. These errors vitiate Mr. Wilson's calculations, but he seems to have made a still more serious one (supposing his data to be correct) in giving 199·32 as the product of the weights into the distances through which they were moved, whereas, if we take the only weights and distances he gives, a very different result follows, namely:—

The transfer of the 9 inch gun = 10437 pounds = 4·66 tons × 20·66 feet = ...	96·27
The transfer of the 11 inch gun = 24159 pounds = 10·78 tons × 7·00 feet = ...	75·49
The transfer of the 20 pounder gun = 3793 pounds = 1·69 tons × 3·665 feet = ...	6·20
	177·96

The moments are thus 177·96, and not 199·32 as given by Mr. Wilson. He does not show how he obtained this 199 32, but merely says the moments amount to that figure. Experiments to be satisfactory and reliable, must have every process clearly described, and all the data exhibited in such manner that each step can be followed and every quantity recalculated. Nothing should be offered on faith. Restating his calculations with corrections, we have

$$\frac{1\frac{1}{2}}{20} = \frac{1}{15} = 3^\circ\ 48'\ 51'' = \cdot 0666$$

$$GM = \frac{pc}{W \text{ tang } \theta} = \frac{177\cdot96}{965\cdot4 \times \cdot0666} = \frac{177\cdot96}{64\cdot386} = 2\cdot765$$ for the distance in feet that the centre of gravity is below the meta centre, and the centre of gravity is consequently 4·80 feet above the centre of displacement which is the real result sought by the experiment, but which he neglects to give. In strictness, the calculations on the vessel should be made to the exact difference of her draughts of water forward and aft, and not from the mean draught.

Mr. Wilson refers to a trial made with the British sailing sloop-of-war "Scylla" for the purpose of determining the position of her centre of gravity. He does not state the result, but the trial and the necessary calculations were made in a very different manner from those of the "Shawmut," and gave, for the position of that centre, 0·42 foot below the load water-line; while, in the case of the steamer "Shawmut," it seems to be 0·38 foot above, provided the experiment had been made with more accuracy than the calculations based on it.

Apart from the errors of calculation, the conduct of the experiment was such as to allow of nothing more than a very rough approximation to the truth. Such a trial to be of any value must be made in a dock or basin where there is no current and during a perfect calm, the vessel being free from moorings and merely held by lines. She should also be inclined both ways and to varying inclinations, and the mean of the determinations taken. In the case of the "Shawmut," however, the vessel was anchored in a stream, and the wind is stated to have blown a little fresh, which must have caused some rolling, but no effort appears to have been made to measure it. The fact that the vessel was riding with an anchor down, must have seriously affected the result; while nothing is said of the current which in the narrow and crooked channel of the river must have had influence and may have combined with the wind to increase or diminish the inclination. And then, only one inclination was tried which is altogether insufficient. As the pivot-gun formed a large portion of the inclining weight, the distance of the centre of gravity of its slide and of its carriage should have been given separately, as well as that of the gun, for they are at very different distances from the pivot or axis of motion. This seems to have been neglected, as only the distance the gun was moved is mentioned.

The principle on which the centre of gravity of a vessel is experimentally ascertained, is so simple that an extended explanation is not necessary, as easily appears from the following:—

If D represents the displacement of a vessel, p the meta centric height, and a the height of the centre of gravity above the centre of displacement or centre of buoyancy; then, if the vessel be inclined through the small angle θ, the expression $D(p-a)\sin\theta$ is the measure of stability at that inclination, provided it be so small that p may be taken as the initial metacentric height without sensible error. If

this inclination produced by placing a weight, w, at a distance, d, from the vertical longitudinal plane, then we have the equality

$$D(p-a)\sin\theta = wd\cos\theta.$$

$$p-a = \frac{wd\cos\theta}{D\sin\theta} = \frac{wd\cos\theta}{D} \text{ or } \frac{wd}{D\,\text{tang}\,\theta}$$

$$\text{whence, } a = p - \frac{wd}{D\,\text{tang}\,\theta}$$

This is the usual and proper expression for the height of the centre of gravity above the centre of displacement.

In calculating the displacement of vessels, the United States' ton of 2240 pounds is used both in this country and in England. The 35 cubic feet used to represent a ton in the English books from which Mr. Wilson so extensively copies, shows this, and is adapted merely for simplicity of calculation, though not correct, as it makes the specific gravity of sea-water 1024, and thus gives a small error of immersion on the safe side. The French naval architects always assume the specific gravity of sea-water at 1026, which is nearer the truth. The French ton is 1000 kilograms, or 2204·737 pounds, which closely approximates the English ton.

Other errors could be noted, but enough have been pointed out to show the utter worthlessness of the experiment, which both in its method and in the calculations based on it exhibit a want of knowledge of the true principles governing such an investigation. The science of the Navy Department must have been rated very low for such a report to have been submitted to it.

The U. S. Commission on tests of Iron and Steel.—Committee F, "On the effects of temperature," requests information as to the behavior of rails and machinery exposed to the extremes of temperature in northern latitudes, when subject to wear or breakage. Information of any kind on the subject, such as specimens, photographs, results of analysis, statistics of railroads, statements of manufacturers, essays, etc., may be sent to the chairman, R. H. Thurston, Stevens' Institute, Hoboken, N. J.

EXPERIMENTS MADE AT THE MARE ISLAND NAVY-YARD, CALIFORNIA, WITH DIFFERENT SCREWS APPLIED TO THE UNITED STATES STEAM LAUNCH NO. 4, TO ASCERTAIN THEIR RELATIVE PROPELLING EFFICIENCY.

By Chief Engineer B. F. Isherwood, U. S. N.

[Continued from Vol. lxix, page 405.]

In the columns of the following table, among others, will be found the frictional resistance of the immersed external surface of the hull; its resistance in function of form, and the variations of the latter from the law of the proportionality of the resistance to the square of the speed from 5·0 to 8·5 geographical miles per hour, both inclusive.

From the table, it will be seen that the variation of the resistance of the hull in function of form alone, is irregular, and very great from the law of its proportionality to the squares of the speeds, alternately decreasing and increasing. That variation is shown numerically in the last column of the table, in per centum of what the resistance would have been according to the above law; the prefixes of minus and plus indicate that the variation is below or above the law.

From the speed of 5·0 geographical miles per hour, the resistance increased in a less ratio than the law of the squares, up to the speed of 5·6 geographical miles per hour where the difference was 12 50 per centum less than what the law of the squares required. From the speed of 5·6 geographical miles per hour, the variation from the law slowly decreased until, at the speed of nearly 6·1 geographical miles per hour, the resistance was in accord with the law. From the latter speed, the resistance rapidly increased above that due to the law up to the speed of 7·8 geographical miles per hour, where it was 77·04 per centum greater than was due to the law. From the speed of 7·8 geographical miles per hour, the variation from the law decreased until, at the speed of 8·5 geographical miles per hour, the resistance was 62 per centum greater than was due to the law.

The resistance of the vessel at the different speeds was not only affected by the speed, but also, and greatly, by the action of the screw,

Speeds of the vessel, in geographical miles per hour.	Squares of the speeds of the vessel, proportionally.	Resistances of the vessel at the different speeds.				
		Resistance of the vessel, in pounds.	Frictional resistance of the external immersed surface of the hull, in pounds.	Resistances of the vessel in function of form alone.		
				In pounds.	Proportionally.	Per centum of the resistance of the hull in function of form due to the law of its proportionality to the sq. of the speed, which the experimental resistance varied from that law.
5·0	1·0000	315·4	220·1	95·3	1·0000	.....
5·1	1·0404	323·3	229·0	94·3	0·9895	— 4·89
5·2	1·0816	333·2	238·1	95 1	0·9979	— 7·74
5·3	1·1236	344·1	247·3	96·8	1·0158	— 9·59
5·4	1·1664	356·0	256·8	99·2	1·0409	—10·76
5·5	1·2100	368·8	266·4	102·4	1·0745	—11·20
5·6	1·2544	380·7	276·1	104·6	1·0976	—12·50
5·7	1·2996	397·5	286·1	111·4	1·1689	—10·05
5·8	1·3456	414·3	296·2	118·1	1·2392	— 7·91
5·9	1·3924	431·1	306·5	124·6	1·3074	— 6·10
6·0	1·4400	449·9	317·0	132·9	1·3945	— 3.16
6·1	1·4884	470·7	327·7	143·0	1·5005	+ 0·81
6·2	1·5376	490·4	338·5	151·9	1·5939	+ 3·66
6·3	1·5876	513·2	349·5	163·7	1·7177	+ 8 19
6·4	1·6384	536·9	360·7	176·2	1·8489	+12·85
6·5	1·6900	560·6	372·0	188·6	1·9790	+17·10
6·6	1·7424	587·3	383·6	203·7	2·1375	+22·68
6·7	1·7956	616·0	395·3	220·7	2·3158	+28 97
6·8	1·8496	644·7	407·2	237·5	2·4921	+34·74
6·9	1·9044	676·3	419·2	257·1	2·6978	+41·66
7·0	1·9600	707·0	431·5	275·5	2·8909	+47·50
7·1	2·0164	739·6	443·9	295·7	3·1028	+53·88
7·2	2·0736	773·2	456·5	316·7	3·3232	+60·26
7·3	2·1316	805·8	469·2	336·6	3·5320	+65·69
7·4	2·1904	836·5	482·2	354·3	3·7177	+69·73
7·5	2·2500	867·1	495·3	371·8	3·9014	+73·40
7·6	2·3104	895·8	508·6	387·2	4·0630	+75·86
7·7	2·3716	920·5	522·1	398·4	4·1805	+76·27
7·8	2·4336	946·3	535·7	410·6	4·3085	+77·04
7·9	2·4964	967·0	549·5	417·5	4 3809	+75·49
8·0	2·5600	990·8	563·5	427·3	4 4837	+75·14
8·1	2 6244	1009·5	577·7	431·8	4·5310	+72·65
8·2	2·6896	1027·3	592·1	435·2	4 5666	+66·07
8·3	2·7556	1043·2	606·6	436·6	4·5813	+66·26
8·4	2·82'4	1057·0	621·3	435·7	4·5719	+61·99
8·5	2·8900	1082·4	636·2	446·2	4·6820	+62 01

the slip of which operated to excavate the water at the stern; and, as the slip of the screw in per centum of its axial velocity increased with the speed of the vessel, this cause was aggravated in producing at the higher speeds the great variation of the resistance of the hull above the law of its proportionality to the squares of the speeds.

Of the influence of the number of blades into which the same area of the same kind of screw-surface is divided, and of their position.—Screws A, E, and F have exactly the same diameter, pitch, and surface; their only variation being in the number of blades into which that surface is divided. Screw A has two blades, one directly opposite the other. Screw E has four blades, arranged in pairs; the blades of each pair are directly opposite each other, and each pair is at right angles to the other. Screw F is a Mangin screw, sometimes called a duplex screw. It is composed of the two pairs of blades of screw E, with one pair placed directly behind the other, so that when viewed in projection on a plane at right angles to the axis of the screw, they appear as only one pair. This was effected by revolving the after pair of blades upon the shaft, until it came in exact projection with the forward pair.

The propelling efficiency of these three screws is exactly the same. They all give an identical slip for the same speed of vessel; and, as their surface is the same in area and in kind, and as they make equal revolutions for equal speeds, the power absorbed by their surface in overcoming the cohesive resistance of the water must be equal.

From these results the inference is warranted that, *in the case of screws having the same kind and quantity of surface, their propelling efficiency, in smooth water, is not affected by either the number or the position of their blades.*

The above equality of effect is limited strictly to the case of *smooth water*, because, in rough water, the superiority in propelling efficiency of the four-bladed over the two-bladed screw, both having the same kind and quantity of surface, is well established. This superiority results wholly from the pitching of the vessel in rough water, whereby, during a given portion of the time, a greater portion of the two-bladed screw is raised out of the water than of the four-bladed screw.

Were the entire pitch used, that is to say, did the screw-surface fill its entire disk when projected on a plane at right angles to its axis, the equality of effect of screws of different numbers of blades, but otherwise the same, would be equal both in smooth and in rough

water; but when only a small fraction of the pitch (from $\frac{1}{4}$ to $\frac{1}{3}$ as in the case in practice) is used, this equality no longer obtains, and the fewer the number of blades into which the surface is distributed, the less becomes the propelling efficiency in rough water. For illustration, take the extreme case of a screw having only one blade, and using only, say, one-fourth of the pitch, a moderate degree of pitching by the vessel would keep the whole of this surface out of the water during one-half of the time; if, however, the same quantity and kind of surface were distributed in two blades placed opposite each other, only one-half of the surface could be kept out of the water one-half of the time, and with four equidistant blades, a still less portion of the surface would be thus inoperative.

In the following table will be found the slips of screws A, E, and F, for the speeds of vessel from 5·0 geographical miles per hour to 8·5, increasing by one-tenth of a geographical mile per hour. These slips are taken from the curve obtained in the manner hereinbefore described, and they are expressed in per centum of the axial speed of the screw:

Speed of the vessel in geographical miles per hour.	Slip of the screw in per centum of its speed.	Speed of the vessel in geographical miles per hour.	Slip of the screw in per centum of its speed.	Speed of the vessel in geographical miles per hour.	Slip of the screw in per centum of its speed.	Speed of the vessel in geographical miles per hour.	Slip of the screw in per centum of its speed.
5·0	7·82	5·9	8·79	6·8	9·76	7·7	12·28
5·1	7·92	6·0	8·87	6·9	9·93	7·8	12·63
5·2	8·03	6·1	8·96	7·0	10·10	7·9	12·95
5·3	8·15	6·2	9·08	7·1	10·33	8·0	13 33
5·4	8·26	6·3	9·19	7·2	10·60	8·1	13·65
5·5	8·37	6·4	9 30	7·3	10·88	8·2	13·91
5·6	8·49	6·5	9·40	7·4	11·20	8·3	14·16
5·7	8·59	6·6	9·50	7·5	11·56	8·4	14·38
5·8	8·69	6·7	9·62	7·6	11·92	8·5	14·57

Had the resistances of the vessel at different speeds been in the ratio of the squares of those speeds, and had the water acted on by the screw continued in the same condition at those different speeds, then the slip of the screw would have been constant, retaining the same per centum of its axial speed at all speeds of vessel. But, as the vessel's resistance at different speeds varied from the law of the square of the speed and as the water on which the screw acted did not continue in the same condition at different speeds of vessel,

not filling the watery furrow made by the passage of the vessel, as rapidly at the higher speeds as at the lower, the screw's slip will vary accordingly to the value of those two causes.

Of the slips of screws of the same kind of surface, but of different quantities of surface.—Screw B, C, and D have the same diameter, pitch, number and form of blades as screw A, differing from it only in quantity of surface. The helicoidal surface of screw A is 6·1321 square feet; of screw B, 4·8078 square feet; of screw C, 3·0661 square feet; and of screw D, 1·7417 square feet. An examination of their slips for equal speeds of vessels, relatively to their surfaces, will detect the law which determines their slips in function of their surfaces. This examination having been made for the experimental slips of each of the above screws, taken from its separate curve of slips, as hereinbefore described, for each speed of vessel from 5·0 geographical miles per hour to 8·5, increasing by one-tenth of a geographical mile per hour, there results the following law: *The absolute slips of screws having the same kind of surface and differing only in its quantity, are for the same speed of the same vessel in the ratio of the square roots of their surfaces.* By absolute slip is meant the speed of the water-current, in geographical miles per hour, (not in per centum,) caused by the screw in the exactly opposite direction to the vessel's course, and due to the mobility of the water in furnishing a fulcrum for the action of the screw.

The *rationale* of the above law is—

1st. That the resistance of water to motion is as the square of the impressed velocity.

2d. That the resistance of the water to the advance of the vessel is equilibrated by the resistance of the water to the thrust of the screw.

3d. That, let the surface of the screw be what it may, the resistance of the water equilibrating its thrust is equal.

4th. That, the water, being a liquid, yields by virtue of its mobility to the thrust of the screw, and that the velocity or absolute slip, thus imparted to the water by the thrust of the screw, will be such that the product of the square of this velocity of the water and of the surface of the screw will be constant for a given speed of vessel.

Now, if S = the surface of the screw, and V = the velocity of the water, or absolute slip of the screw, for any given speed of the vessel, then $S \times V^2$ will be a constant for that speed of vessel; and if the

value of S be changed, then, to maintain the constancy of the product $S \times V^2$, the value of V must be changed in the inverse ratio of the square roots of S in the two cases.

For example: Let S = 25 square feet, and V = 2 geographical miles per hour with any given speed of vessel: then, $25 \times 2^2 = 100$ = the constant. Now, if S be reduced to 9 square feet, then to find the value of V in the new case, the speed of the vessel remaining as before, we have $\sqrt{9} : \sqrt{25} :: 2 : 3\frac{1}{3}$ geographical miles per hour, which is the velocity of the water pressed by the new screw surface 9 square feet, to give the vessel the same speed as before, because $3\frac{1}{3}^2 \times 9 = 100$ = the constant.

When the speed of the vessel and the absolute slip of the screw are know in geographical miles per hour, the relative slip of the screw, that is to say, its slip proportionally to its axial speed, is easily obtained and is usually expressed in per centum of the latter. For example, suppose in the first of the above cases that the speed of the vessel was 8 geographical miles per hour and the absolute slip of the screw 2 geographical miles per hour, then the axial speed of the screw would be (8 + 2 =) 10 geographical miles per hour, of which 2 geographical miles per hour is 20 per centum, and this would be the slip of the screw. Now, in the second of the above cases, when the surface of the screw was reduced, but the speed of the vessel remained constant, the absolute slip of the screw being $3\frac{1}{3}$ geographical miles per hour, and the vessel's speed being 8 geographical miles per hour as before, the axial speed of the screw becomes (8 + $3\frac{1}{3}$ =) $11\frac{1}{3}$ geographical miles per hour, and the slip of the screw becomes 29·41 per centum of its axial speed. By its axial speed is meant the product of its pitch and the number of revolutions made by it in a given time. This product is equal to the sum of the vessel's speed and that of the absolute slip of the screw.

When the speed of the vessel is given in geographical miles per hour, and the slip of the screw is given in per centum of the unknown axial speed of the screw, the slip of the screw in geographical miles per hour can be obtained from the following considerations:

Assuming the unknown axial speed of the screw to be represented by 100, its slip being known proportionally to this number, or in per centum of the screw's speed, the vessel's speed will be represented relatively to that of the slip by the difference between these two quantities, so that we thus have the speed of the slip and the speed of the vessel expressed proportionally; whence, as the absolute

speed of the vessel per hour in geographical miles is given, the absolute speed of the slip of the screw in geographical miles per hour will be obtained by the simple proportion, as the vessel's speed in per centum of the screw's speed, is to the screw's slip in per centum of the screw's speed, so is the vessel's absolute speed in geographical miles per hour, to the screw's absolute slip in geographical miles per hour.

For example, suppose the known slip of the screw to be 20 per centum of the screw's unknown axial speed, and the known speed of the vessel to be 8 geographical miles per hour, then the speed of the vessel relatively to the unknown speed of the screw will be (100 — 20 =) 80, and the proportion for obtaining the absolute slip of the screw in geographical miles per hour will be 80 : 20 :: 8 : 2, the screw's slip in geographical miles per hour.

The surface of the screw may be the helicoidal surface, or its projection on a plane at right angles to or parallel with the axis, or it may be expressed by the fraction used of the pitch. Any of these quantities may be used, so long as the same ones are continued throughout, the screw-blade having, of course, the same form or outline in all cases. That is to say, if its front and back edges are parallel and at right angles in one case, they are to remain so for the other cases.

Of the influence on the slip of the screw due to curving the front and back edges of its blades to the Griffith form, and to substituting a globe for the central portion of the screw-surface.—Screw H was made from screw G by cutting the forward and after edges of the latter to the Griffith form, and by bolting upon the hub between the blades pieces of wood accurately fitted to those spaces, forming a globe around the screw's axis of 1·25 feet diameter, equal to 28·85 per centum of the screw's diameter. The diameter of the hub of screw H was 11·54 per centum of the screw's diameter. As screw G had a pitch continuously expanding from the forward edge of its blades to the after edge, the result of cutting off surface at those edges was to slightly increase the initial and lessen the final pitch for screw H, leaving the mean pitch unchanged, and, consequently, the same in both screws H and G. The change of pitch thus made was not material in its effect upon the slip. The reduction of surface, however, was considerable, both at the centre and at the periphery of the screw, and its effect was to greatly increase the slip, raising it from 18·48 per centum, when the vessel's speed was 8·5 geographical miles an hour, to 21·99 per centum, of the screw's axial speed.

(To be continued.)

DESTRUCTION OF THE RAILROAD BRIDGE OVER THE BIG BLACK RIVER

By Wm. E. Morris, Civil Engineer.

About the year 1839 there was erected upon the Railroad between Vicksburg and Jackson, Mississippi, a high bridge across the Big Black River.

It was destroyed during the recent war and rebuilt in 1865 and '66. There were three spans, respectively 105, 140 and 165 feet in length, supported upon three high piers and one small abutment pier.

The two middle piers stood in the bed of the river, the eastern one upon a low flat of land not many feet above surface of low water, while the western one, serving as an abutment, was built upon a steep clay bank that formed the western shore of the river.

The abutment was built of brick, about 10 feet in height, while the middle piers had a height of about 80 feet, the lower 25 feet constructed of granite and the upper 55 feet of brick masonry.

Upon the eastern side the approach to the bridge was upon a high trestle work.

The bridge was rebuilt upon the "Fink Plan," with wooden chords, wrought iron suspension rods and cast iron bearing columns, with the road-way carried upon the chords. This was the most important and expensive structure upon the road, and its stability and permanence was justly considered by the officers of the company, of great moment.

After the annual meeting of the company, on the first Monday of May, 1874, the president, several of the directors, the superintendent of the road and myself, visited the bridge and found it in good condition, though the water of the river was quite high, some 25 feet above low water.

Ten days afterwards, the west bank of the river, both below the west abutment and in its rear, began to crack and slide slowly into the river. This continued until the abutment slid out of its position obliquely down the bank, throwing upon the sloping bank below, the western span of the bridge.

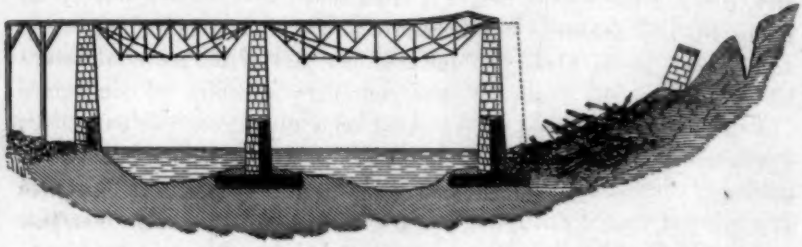
Two days afterwards the western pier was noticed to be moving bodily eastward, latterally. This it continued to do for several days,

until it had moved six feet, when the second span was thrown down. This movement of the pier brought the top of the masonry against the suspension rods of the bridge, pressing them upwards and carrying with them the first bearing columns and breaking the cords immediately over their top, which precipitated the second span into the river.

The pier kept its vertical position perfectly, and apparently did not sink. By an examination recently made, a year after the catastrophe, the pier is found to have moved about one foot farther, and still keeps its vertical position and its apparent altitude.

This pier, as before stated, was built more than thirty years ago, and during all that time had stood permanently, and safely carried its load. By the estimate of the resident engineer of the road, the pier contains about 2,500 tons of masonry.

It is understood to have been built upon two courses of heavy timber, laid crosswise.



Upon examination along the western shore of the stream, the cracking of the bank, and its sliding into the river was found to have extended some two or three hundred feet, both above and below the site of the bridge.

The immediate cause of the sliding of the bank was no doubt its thorough saturation with water from rains, and the high floods of the river; but this has almost annually been the case heretofore, and frequently the rains were heavier and the floods higher. It is evident that the material upon which the moved pier rested was moved in a body by the pressure of the sliding bank of the river.

This sliding mass did not accumulate and press against the side of the pier.

The above cut will serve farther to explain this remarkable occurrence.

Chemistry, Physics, Technology, etc.

REPORT ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.*

By Dr. A. W. Hofmann.†

The Elements of Water.‡ By Dr. A. Oppenheim.

Oxygen.—Like the evolution of human life, the development of every chemical art is connected with oxygen; Directly or indirectly, it intervenes in every manufacturing operation. With equal necessity, life and technology derive it from that exhaustless source of all being, the atmosphere. Furthermore, no discovery has had a greater significance for the history of culture than that of the material nature of the air, and the discovery—the centenary of which we commemorate this year—of its most important constituent, oxygen gas.‖ To the same discoveries chemical industry owes its rational foundation and the possibility of its advancement, and thus both the existence and the progress of technology are linked to the same element. What, in comparison with these incalculable benefits, are the advantages which pure oxygen gas has conferred upon industry by its direct application? To give a reply to this question is the object of the following lines, and as no reports or text-books have hitherto treated this subject in a connected manner, we may venture to exceed in point of time the boundaries of this report.

Lavoisier, who first recognized in its full extent the importance of oxygen, took the first successful step in its technical application.

* "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

† From the *Chemical News*.

‡ "Die Elemente des Wassers."

‖ "On the 1st of August, 1774, I endeavored to extract air from mercurius præcipitatus per se."—Joseph Priestley, "Experiments and Observations on Air," ii 106. See also Kopp, "Geschichte der Chemie," iii, 200 and 204.

"It is evident," he writes,* "that atmospheric air is not the most suitable to increase the action of fire, and that, if we drive a current of air upon ignited fuel by means of bellows, three parts of injurious, or at least useless, gas are driven in for one part of the serviceable kind of air, and that, therefore, if the latter could be used for combustion in a pure state, the action of the fire would be much enhanced. This idea has doubtless occurred to many persons prior to myself, and I hear that Archard, the celebrated chemist of Berlin, has carried it into application;† but it is still needful to devise a cheap and convenient apparatus."

For this purpose, Lavoisier used at first bladders fitted with tubes and taps. "I made," he continues, "with a knife, a hole three to four lines deep in a large piece of charcoal, and laid in it 6 grs. of platinum, set fire to the charcoal at an enameler's lamp by means of a blowpipe, opened the jet of my apparatus, and blew pure oxygen into the hollow. The charcoal burnt very rapidly, with detonation as it produces with melted saltpeter, and with a dazzling brilliance; and in a few moments the platinum melted into granules, which then united into a ball. The fusion was equally successful, whether the ordinary platinum of commerce was taken or such as had been previously freed from magnetic particles by means of a magnet. Hitherto, platinum has not been melted."

Lavoisier improved his apparatus in the same year,‡ in conjunction with Meusnier, and produced a gasometer consisting of two boxes, and which on a small scale much resembled those now in use at gas-works. About the same time, Saron constructed two blowpipes (*chalumeaux*), one of which delivered oxygen and the other hydrogen. By their means, however, Lavoisier did not succeed in fusing platinum.‖ He hoped, however, to construct an improved blow pipe, in which the oxygen should surround the hydrogen, and thus was developed the plan of the oxyhydrogen blowpipe, which has rendered such essential service in the metallurgy of platinum and in soldering lead.

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* "Memoire sur un Moyen d'Augmenter Considérablement l'Action du Feu et de la Chaleur dans les Operations Chimiques."—"Oeuvres de Lavoisier ii, 425.

† *Memoiren der Berliner Academie*, 1779. "Sur un Nouveau Moyen de Produire avec une très Petite Quantité de Charbons une Chaleur," etc.

‡ Lavoisier, "Oeuvres," ii, 432.

‖ Lavoisier, "Oeuvres," ii, 430.

The application of oxygen for melting platinum remained dormant until, in 1857 to 1859, Deville and Debray made known their important investigations * on the platinum metals, and introduced the industrial fusion of platinum. The autogenous soldering of platinum, and the production of fused ingots on the large scale, was first carried out by Johnson, Matthey, & Co., of London, and also by Heraeus, of Hanau, in Germany.

Debray's and Deville's experiments led, above all, to the discovery of a refractory material for crucibles and furnaces. For this purpose quick-lime offered itself, which has the further advantage of retaining the heat as completely as possible. The chemists aboved-named increased the heat further by leading the flame from above directly upon the surface of the metal, and determined the amounts of oxygen and hydrogen theoretically and practically necessary for melting 2 kilos. of platinum, *i. e.*, by calculation, 55 liters of oxygen and 110 of hydrogen. The amount actually fused was more than 1 kilo, so that —a highly favorable result—not 50 per cent. of the heat produced was wasted. These experiments had a further bearing upon the industrial history of oxygen, as they led to the comparison of the cost of the methods of its production and to the search for a less expensive process. We may divide the known methods into chemical and mechanical, subdividing the former into continuous and interrupted procedures.

Up to this time, the following methods of preparation were either in use, or had been proposed :—The original process of Priestley, heating oxide of mercury, of course, the most expensive, and the least suited for technological purposes; then Scheele's method, treatment of peroxide of manganese with sulphuric acid, the result being manganous sulphate and oxygen. On the large scale, since the investigations of Berthier in 1822, this was replaced by the simple ignition of manganese, and finally the action of heat upon the chlorate of potash. The last-mentioned process, in spite of its costliness, has become established for laboratory operations, as being convenient and requiring only a small supply of heat, although it has frequently occasioned explosions when the gas was being too rapidly liberated. To prevent such accidents, it has been repeatedly proposed to mix manganese

* Deville and Debray, 1859, *Ann. Chim. Phys.*, lvi, 385. *Dingler's Polyt. Journ.* cliv, 130, 199, 287, 383.

with the chlorate of potash. Recent accidents, especially a fearful explosion in a pharmaceutical laboratory in Paris, induced Debray and Bourgoin* to make known the precautions used in Deville's laboratory. Manganese, or the red manganoso-manganic oxide (Mn_3O_4), which is more easily obtained in a state of purity, is mixed with the chlorate of potash in equal weights, and the iron retort is heated in a furnace filled with fuel in such a manner that the fire may be kindled at the top. Schwartz† made known accidents occasioned by the use of manganese adulterated with lampblack, or by the accidental use of the sulphide of atimony instead of manganese, and he therefore very justly recommends that oxygen gas mixture should be previously tested by heating a portion upon platinum foil. Munck‡ proposed to use oxide of iron instead of manganese, as being more easily distinguished.

Scheele's process—the mutual action of manganese and sulphuric acid—has the disadvantage that the glass is often broken by the congelation of the manganous sulphate. To prevent this, Wagner‖ proposes to use, instead of sulphuric acid, bisulphate of soda. An easily fusible double salt is thus formed which does not break the glass as it cools. Pure peroxide of manganese, when thus treated, evolves 18 per cent. of oxygen, but only 12 per cent. if ignited, when it is converted into sesquioxide. Nevertheless, the latter process is the more economical. Deville and Debray§ calculate the expense according to the source of the manganese, as follows:—

Ten kilos. of Manganese from	Cost. Francs.	Price of 1 cubic metre of O. Francs.
Romaneche,	10	4·86
Spain,	16	3·45
Pyrenees,	18	3·86
Giessen,	27	4·87
Italy,	40	5·98

The trifling value of the residual sesquioxide which contains iron, and is therefore useless in the glass manufacture, is not taken into

* Debray and Bourgoin, *Ber. Chem. Ges. zu Berlin*, 1870, 240.

† Schwartz, *Breslauer Gewerbeblatt*, 1865, 7.

‡ Munck, *Pohl's Lehrbuch der Technologie Wein*, 1865, 186

‖ Wagner, *Jahresberichte*, 1866, 198.

§ Deville and Debray, *Comptes Rendus*, li, 822,

account. This calculation dates from the time when the re-oxidation of manganese was still an unsolved problem. If the price of oxygen obtained from manganese ranges from 3·45 to 5·98 francs it is cheaper by more than one-half than that procured from chlorate of potash, which Dupré * calculates at 10 francs.

Deville and Debray † found a much cheaper source in sulphuric acid, which, at elevated temperatures, is resolved into water, sulphurous acid and water. Retorts containing 5 liters of very infusible glass were partially filled with platinum foil, or with fragments of brick, and heated to redness, whilst sulphuric acid was allowed to flow in in a slender stream. The escaping gases are led through a cooling apparatus in order to condense sulphuric acid, and into water to remove sulphurous acid. By this process 2·436 kilos. of sulphuric acid of the sp. gr. 1·827 yielded 240 litres of oxygen at the expense of 1 franc per cubic meter. On its application the cost of smelting platinum was from 20 to 30 centimes per kilo.

According to a paragraph by Moigno ‡ the firm of José de Susine & Co., of Paris, prepared by this process oxygen at 0·85 franc per cubic meter, re-converting the sulphurous acid into sulphuric acid.

Instead of the free acid Deville and Debray propose the use of sulphate of zinc; 100 kilos. of the anhydrous salt yielded in their experiments 6.8 cubic meters of oxygen,—far more than the best black oxide of manganese—22 kilos. sulphurous acid gas, and 51 kilos. oxide of zinc.

Wagner's statement‖ must be noted that, in the year 1867, both these methods were not carried out in Deville's laboratory, perhaps because the development of sulphurous acid complicated their execution; in fact, they have both been left in the background in industrial practice. As an attempt in that direction, we must notice the procedure of Archereau,§ who employed sulphuric acid in its cheapest combination, gypsum. He maintained that, by heating ground gypsum with sand, he could obtain silicate of lime, whilst sulphurous acid was set free, which he (as also Susini) chiefly condensed by a

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* Dupré, *Compt. Rend.*, lv, 736.

† Deville and Debray, *Compt. Rend.*, li, 822.

‡ *Les Mondes*, 1867, p. 494.

‖ Wagner, *Jahresberichte*, 1867, 216.

§ Archereau, *Dingler's Polyt. Journ.*, clxxviii., 57.

pressure of three atmospheres, and removed the rest by passage through milk of lime. A manufactory on this principle, established at Paris, had but a short career.* The very high temperature required is evidently a hindrance. Probably the oldest source of oxygen, saltpeter, had not been used for the preparation of the gas, for two reasons. On the one hand, the product is largely mixed with nitrogen, and on the other, the temperature required for its decomposition augments the cost of preparation. Webster† overcame the latter difficulty by adding to the nitre oxide of zinc. 20 pounds of soda-saltpeter and 4 pounds of crude oxide of zinc yielded in his hands, 94·676 cubic feet of a mixture of 59 per cent. of oxygen and 41 per cent. of nitrogen, the residue being chiefly oxide of zinc and caustic soda. In this mixture, which is useful for many purposes, the oxygen cost 2·32 francs per cubic meter if the solid residue be neglected; but, if the latter be utilized, the expense of the oxygen falls to 0·78 franc.‡

In all these methods, one of the leading ideas of modern industry, the regeneration of residues, has been neglected. The following proposals are, in this respect, happier, and have, therefore, been partially more successful. To combine the oxygen of the atmosphere chemically with some substance which shall readily give off the combined gas and be again able to take up and give off fresh quantities of oxygen, as is done by the mercury in mercuric oxide; this is the problem which has been solved in the last few years. As early as 1829, Dingler, Junior,‖ observed that both oxide of copper and the peroxides of nickel and cobalt, with an excess of chloride of lime, gave off oxygen, converting the latter substance into chloride of calcium. In 1845, Mitscherlich§ made known the fact that various other metallic oxides, peroxide of manganese, hydrated peroxide of iron, etc., if added to a solution of chloride of lime, occasioned a plentiful liberation of oxygen. In 1865, these observations were renewed by T. H. Fleitmann,** with especial reference to recently prepared sesquioxide, small quantities of which sufficed to decompose completely a concen-

* Wagner, *Jahresberichte*, 1867, 215.

† Pepper, *Chemical News*, 1862, 218.

‡ Dupré, *Comptes Rendus*, lv., 736.

‖ *Dingler's Polyt. Journ.*, xxvi., 231.

§ Mittscherlich, *Pogg. Ann.*, lviii., 471.

** *Ann. Chem. Pharm.*, cxxxiv., 64.

trated solution of chloride of lime into chloride of calcium and oxygen gas. He recommended, in practice, a solution of chloride of lime concentrated as much as possible, and clarified by filtration or deposition to prevent frothing, and then mixed with 0·1 to 0·5 per cent. of its contents of sesquioxide of cobalt, and heated from 70° to 80°. On employing chloride of lime at 35 per cent., he obtained oxygen in a regular stream, to 25 or 30 times the volume of the liquid. Other observers, especially F. Varrentrapp,* confirmed these results, and recommended the industrial adoption of the process. The sesquioxide of cobalt does not require to be manufactured in advance. Any salt of cobalt in solution serves the same purpose, and the sesquioxide settles to the bottom and can be used again in fresh operations.

For the same reason, a cheaper oxide, as for instance, oxide of copper, which Bottger proposes,† offers but little advantage, especially as a higher temperature is required for its decomposition.‡ The trouble of preparing a clear solution of chloride of lime may be dispensed with if, as Stolba suggests, a piece of paraffin of the size of a pea be added to the turbid solution ‖ The thin layer of oil upon the surface prevents frothing. One difficulty yet remains to be removed. Chloride of lime requires considerable quantities of water for solution, and large vessels are, therefore, required for preparing moderate quantities of oxygen. A. Winkler,§ therefore, dispensed with chloride of lime, by using a thick milk of lime with a little salt of cobalt, and treating the mixture with chlorine. By means of this modification, a larger volume of oxygen is evolved with the same vessels, and all danger of frothing over is avoided.

The part played by the metallic oxide in these methods is readily intelligible. It serves as a carrier of oxygen, passing alternately to a higher, readily decomposable, stage of oxidation, and then returning to its original state. The hypochlorous acid of the chloride of lime converts the sesquioxide of cobalt into an unstable cobaltic acid, which is immediately resolved into sesquioxide of cobalt and oxygen.

$$Co_2O_3+3[CaCl(OCl)]=3CaCl_2+2CoO_3=Co_2O_3+O_3.$$

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* *Mittheilungen f. d. Gewerbe Vereins des Herzogthums Braunschweig*, 1865–66, 72.

† Böttger, *Journ. Prakt. Chem.*, xcv., 375.

‡ Reinsch, *Neue Jahr. Pharm.*, xxiv., 94.

‖ Stolba, *Journ. Prakt. Chem.*, xcvii,, 309.

§ A. Winkler, *Journ. Prakt. Chem.*, xcviii., 340.

Thus, one part of the above-stated problem is solved, and the developer of oxygen is re-formed by the very act of developing oxygen. Still the oxygen is obtained, not from the atmosphere, but from the chloride of lime. The solution of chloride of calcium formed must be removed, and replaced by milk of lime. The process, therefore, is not continuous, and in this respect, there is still room for economic simplification.

This, also, has been achieved, and by means of experiments which lead us back from the moist to the dry way. Since 1851,* Boussingault has brought baryta into use as a bearer of oxygen, heating it to redness in porcelain tubes, and treating it with moist air free from carbonic acid, by which it is converted into peroxide of barium. By means of a current of watery vapor, it is re-converted into hydrate of baryta, and oxygen is liberated. An addition of lime or magnesia prevents any incipient fusion, and 75 grams of baryta yield on each operation 4 to 5 liters of oxygen. Gondolo† improved this method in 1868, replacing the porcelain tubes with iron ones, protected by magnesia within and by asbestos without, and laid in suitable furnaces, whose temperature was regulated by dampers, and adding to the baryta a little manganate of potash as well as lime and magnesia. In this manner as many as 122 alternate oxidations and deoxidations were conducted in the same tube. Whether, however, it be due to the high temperature, or to other drawbacks which stand in the way of the industrial application of this method, it has not yet found its way into actual practice.‡

Attention was directed to more sensitive transferrers of oxygen than baryta, and in the first place to chloride of copper. Its property, on exposure to the air, to pass into oxychlorides of various composition, lies at the root of the manufacture of a well known pigment, Brunswick green. In 1855, Vogel proposed the action of hydrochloric acid upon oxychlorides of copper as a source of chlorine.‖ Mallet§ examined these bodies more closely, and in 1867 and 1868, proposed a

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* Boussingault, *Comptes Rendus*, xxxii., 261 and 821,

† Gondolo, *Comptes Rendus*, lxvi., 488.

‡ Robbin, *Pogg. Ann.*, cxxii., 256,

‖ Vogel, Wagner, *Jahresberichte*, 1861, 177.

§ Mallet, *Comptes Rendus*, lxiv., 286, and lxvi., 349.

method for the industrial preparation of chlorine and oxygen. He found that cuprous chloride is converted into oxychloride by a current of steam at from 100° to 200° C., which, in contract with hydrochloric acid, is immediately resolved into cupric chloride and free chlorine, but which, if heated to 400°, gives off all its oxygen. One kilo. of cuprous chloride, yields 28 to 30 liters of oxygen. In experiments on the large scale, 100 kilos. of cuprous chloride yielded either 3 to $3\frac{1}{2}$ cubic meters of oxygen, or 6 to 7 cubic meters of chlorine. As four or five such operations can be conducted daily, 200 to 300 kilos. of cuprous chloride could be made to yield daily, 15 to 18 cubic meters of oxygen. The requisite apparatus consists of rotatory cast iron retorts lined with clay, which contain the cuprous chloride mixed with one-third sand or kaolin to diminish its fusibility. This process was carried out in Cologne in 1871.* A company established at Paris for the utilization of the process flourished for a short time only,† probably because it was superseded by an analogous process.

We refer to the method which has been developed since 1867‡ by the suggestive inventor, Tessié du Motay. Its transferrer of oxygen is the black oxide of manganese, and it is based upon the following reactions: Hydrate of soda, according to Mittscherlich, if heated to dull redness in contact with air and black oxide of manganese, yields manganate of soda and water—

$$4NaOH+2MnO_2+2O=2Na_2MnO_4+2H_2O.$$

Manganate of soda at the same temperature, in a current of dry superheated steam, is resolved again into hydrate of soda, sesquioxide of manganese, and free oxygen—

$$2Na_2MnO_4+2H_2O=4NaOH+Mn_2O_3+3O.$$

The only condition, then, is to free the superheated air previously from carbonic acid, in order to obtain a mixture which shall be perpetually efficient. This method has been found satisfactory on repeated scrutiny, and has been applied on the large scale at Comines (near Lille), at Pantin (near Paris), at New York, Brussels, and Vienna. Bothe‖ reports that a melting of 60 parts of dry carbonate of soda

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* Phillips, "Der Sauerstoff" (Berlin, 1871), 22.

† Wagner, *Jahresberichte*, 1867, 215.

‡ Tessié du Motay, *Institut*, 1868, 48.

‖ Bothe, *Zeitschr. d. Vereins Deutsch. Ing.*, 1867, 334.

with 40 parts of peroxide of manganese, at 95 per cent., yielded, according to analysis, 74·62 of manganate of soda, and that 40 kilos. of this substance, which, according to theory, should yield 2036 cubic decimeters of oxygen, actually produced 1800, or 90 per cent. of the calculated yield. He recommended the process as easy of execution. The most complete description has been given by Pourcel.* According to him, Tessié du Motay employs for retorts cast iron elipsoids, which lie horizontally side by side, and are divided by a grate into two unequal portions parallel with their axis. Upon the grate are spread in each retort, 350 kilos. of manganate of soda, or the corresponding reduced mixture of soda and manganese, in such a manner that its thickness amounts to 0·6 of a metre, and the empty space above and below the mass is as small as possible. In Comines, where five such retorts are in action, the daily production amounted to 140 cubic meters of oxygen, with an expenditure of 450 kilos. of coal for heating the retorts, and 150 kilos. for the steam-engine.

(To be continued.)

THE MECHANICAL ACTION OF LIGHT.

By Wm. Crookes, F.R.S., etc.†

Some experiments illustrating the mechanical action of Light, which I have recently exhibited before the Fellows of the Royal Society, having attracted considerable attention, I propose to give here a description of some of the instruments which my researches have enabled me to construct. But, to render the subject more intelligible, it will be necessary to give a brief outline of the researches which I have been carrying on for the last three or four years, so that the reader may see the gradual steps which have led up to the full proof that Radiation is a motive power.

The experiments were first suggested by some observations made when weighing heavy pieces of glass apparatus in a chemical balance, enclosed in an iron case from which the air could be exhausted. When

* Pourcel, "Mémoires de la Société des Ingénieurs Civiles," P——, 1873.

† The *Quarterly Journal of Science.*

the substance weighed was of a temperature higher than that of the surrounding air and the weights, there appeared to be a variation of the force of gravitation. Experiments were thereupon instituted to render the action more sensible and to eliminate sources of error.*

My first experiments were performed with apparatus made on the principle of the balance. An exceedingly fine and light arm was delicately suspended in a glass tube by a double-pointed needle; and at the ends were affixed balls of various materials. Amongst the substances thus experimented on, I may mention pith, glass, charcoal, wood, ivory, cork, selenium, platinum, silver, aluminium, magnesium, and various other metals.

The most delicate apparatus for general experiment was made with a straw beam having pith masses at the end. The general appearance of the apparatus is shown in Fig. 1.

a is the tube belonging to the Sprengel pump.† *b* is the desiccator, full of glass beads moistened with sulphuric acid. *c* is the tube containing the straw balance with pith ends; it is drawn out to a contracted neck at the end connected with the pump, so as to readily admit of being sealed off at any stage of the exhaustion. *d* is the pump-gauge, and *e* is the barometer.

The whole being fitted up as here shown, and the apparatus being full of air to begin with, I passed a spirit-flame across the lower part of the tube at *b*, observing the movement by a low-power micrometer; the pith ball (*a b*) descended slightly, and then immediately rose to considerably above its original position. It seemed as if the true action of the heat was one of attraction, instantly overcome by ascending currents of air. A hot metal or glass rod and a tube of hot water applied beneath the pith ball at *b* produced the same effect as the flame; when applied above at *a*, they produced a slight rising of the ball. The same effects take place when the hot body is applied to the other end of the balanced beam. In these cases, air currents are sufficient to explain the rising of the ball under the influence of heat.

In order to apply the heat in a more regular manner, a thermometer was inserted in a glass tube, having at its extremity a glass bulb about 1½ inches diameter; it was filled with water and then sealed up (see Fig. 2). This was arranged on a revolving stand, so that by means

* "On the Atomic Weight of Thallium," Phil. Trans., 1873, vol. clxiii, p. 287.

† For a full description of this pump, with diagrams, see Phil. Trans., 1873, vol clxiii, p. 295.

Fig. 1.

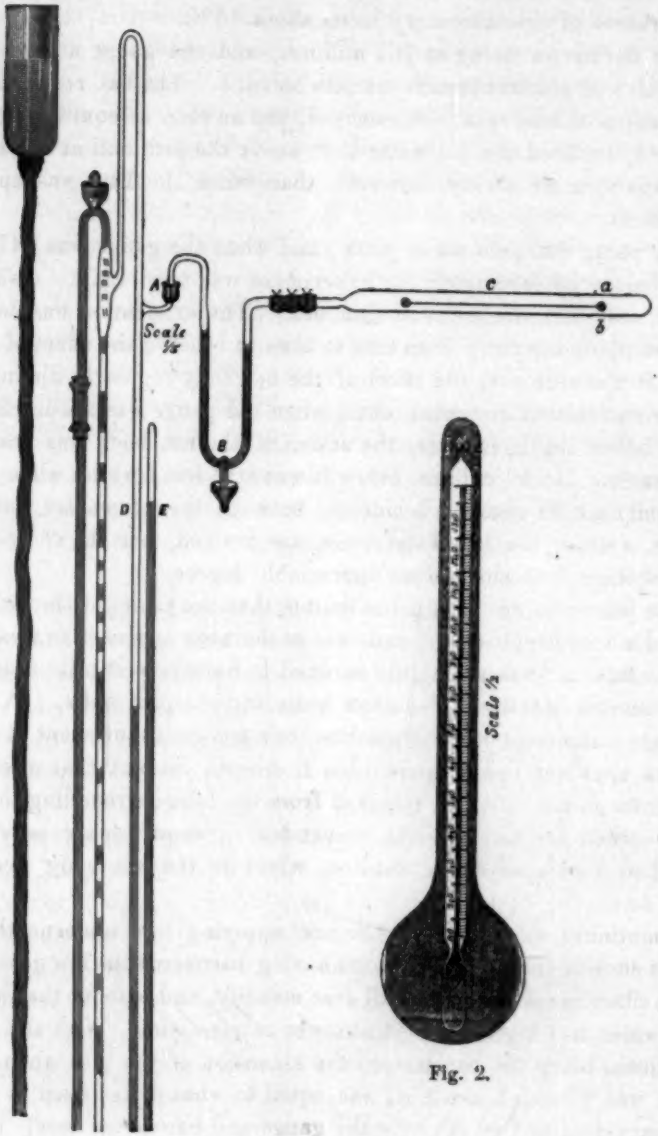

Fig. 2.

of a cord, I could bring it to the desired position without moving the eye from the micrometer. The water was kept heated to 70°C., the temperature of the laboratory being about 15°C.

The barometer being at 767 millims., and the gauge at zero, the hot bulb was placed beneath the pith ball at *b*. The ball rose rapidly. The source of heat was then removed, and as soon as equilibrium was restored, I placed the hot water bulb above the pith ball at *a*, when it rose again, more slowly, however, than when the heat was applied beneath it.

The pump was then set to work; and when the gauge was 147 millims. below the barometer, the experiment was tried again; a similar result, only more feeble, was obtained. The exhaustion was continued, stopping the pump from time to time to observe the effect of heat, when it was seen that the effect of the hot body regularly diminished as the rarefaction increased, until, when the gauge was about 12 millims. below the barometer, the action of the hot body was scarcely noticeable. At 10 millims. below it was still less; whilst when there was only a difference of 7 millims. between the barometer and the gauge, neither the hot water bulb, the hot rod, nor the spirit-flame caused the ball to move in an appreciable degree.

The inference was almost irresistible that the rising of the pith was only due to currents of air, and that at this near approach to a vacuum the residual air was too highly rarefied to have power in its rising, to overcome the inertia of the straw beam and the pith balls. A more delicate instrument would doubtless show traces of movement at a still nearer approach to a vacuum; but it seemed evident that when the last trace of air had been removed from the tube surrounding the balance—when the balance was suspended in empty space only—the pith ball would remain motionless, wherever the hot body were applied to it.

I continued exhausting. On next applying heat underneath, the result showed that I was far from having discovered the law governing these phenomena; the pith ball rose steadily, and without that hesitation which had been observed at lower rarefactions. With the gauge 3 millims. below the barometer, the ascension of the pith when a hot body was placed beneath it, was equal to what it had been in air of ordinary density; whilst with the gauge and barometer level, its upward movements were not only sharper than they had been in air, but

they took place under the influence of far less heat—the finger, for example, instantly repelling the ball to its fullest extent.

To verify these unexpected results, air was gradually let into the apparatus, and observations were taken as the gauge sank. The same effects were produced in inverse order, the point of neutrality being when the gauge was about 7 millims. below a vacuum.

A piece of ice produced exactly the opposite effect to a hot body.

The presence of air having so marked an influence on the action of heat, an apparatus was fitted up in which the source of heat (a platinum spiral rendered incandescent by electricity) was inside the vacuum-tube instead of outside it as before; and the pith balls of the former apparatus were replaced by brass balls. By careful manipulation and turning the tube round, I could place the equipoised brass ball either over, under, or at the side of the source of heat. With this apparatus I tried many experiments, to ascertain more about the behavior of the balance during the progress of the exhaustion, both below and above the point of no action, and also to ascertain the pressure corresponding with this critical point.

In one experiment, which is described in detail in my paper on this subject before the Royal Society,* the pump was worked until the guage had risen to within 5 millims. of the barometric height. On arranging the ball above the spiral and making contract with the battery, the attraction was still strong, drawing the ball downwards a distance of 2 millims. The pump continuing to work, the guage rose until it was within 1 millim. of the barometer. The attraction of the hot spiral for the ball was still evident, drawing it down when placed below it, and up when placed above it. The movement, however, was much less decided than before; and in spite of previous experience the inference was very strong that the attraction would gradually diminish until the vacuum was absolute, and that then, and not till then, the neutral point would be reached. Within 1 millim. of a vacuum there appeared to be no room for a change of sign.

The guage rose until there was only $\frac{1}{2}$ a millim. between it and the barometer. The metallic hammering heard when the rarefaction is close upon a vacuum commenced, and the falling mercury only occasionally took down a bubble of air. On turning on the battery current, there was the faintest possible movement of the brass ball (towards the spiral) in the direction of attraction.

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* Phil. Trans., 1874, vol. clxiv, p. 501.

The working of the pump was continued. On next making contact with the battery, no movement could be detected. The red-hot spiral neither attracted nor repelled. I had arrived at the critical point. On looking at the guage I saw it was level with the barometer.

The pump was now kept at full work for an hour. The gauge did not rise perceptibly; but the metallic hammering sound increased in sharpness, and I could see that a bubble or two of air had been carried down. On igniting the spiral, I saw that the neutral point had been passed. The sign had changed, and the action was one of faint but unmistakable *repulsion*. The pump was still kept going, and an observation was taken from time to time during several hours. The repulsion continued to increase. The tubes of the pump were now washed out with oil of vitriol,* and the working was continued for an hour.

The action of the incandescent spiral was now found to be energetically *repellent*, whether it was placed above or below the brass ball. The fingers exerted a repellent action, as did also a warm glass rod, a spirit-flame, and a piece of hot copper.

In order to decide once for all whether these actions really were due to air-currents, a form of apparatus was fitted up which—whilst it would settle the question indisputably—would at the same time be likely to afford information of much interest.

By chemical means I obtained in an apparatus a vacuum so nearly perfect that it would not carry a current from a Ruhmkoff's coil when connected with platinum wires sealed into the tube. In such a vacuum the repulsion by heat was still found to be decided and energetic.

I next tried experiments in which the rays of the sun, and then the different portions of the solar spectrum, were projected on to the delicately suspended pith ball balance. *In vacuo* the repulsion by a beam of sunlight is so strong as to cause danger to the apparatus, and resembles that which would be produced by the physical impact of a material body.

A simpler form of the apparatus for exhibiting the phenomena of attraction in air and repulsion in a vacuum consists of a long glass

* This can be effected without interfering with the exhaustion.

tube, *a b* (Fig. 3), with a globe, *c*, at one end. A light index of pith, *d e*, is suspended in this globe by means of a cocoon fiber.

Fig. 3.

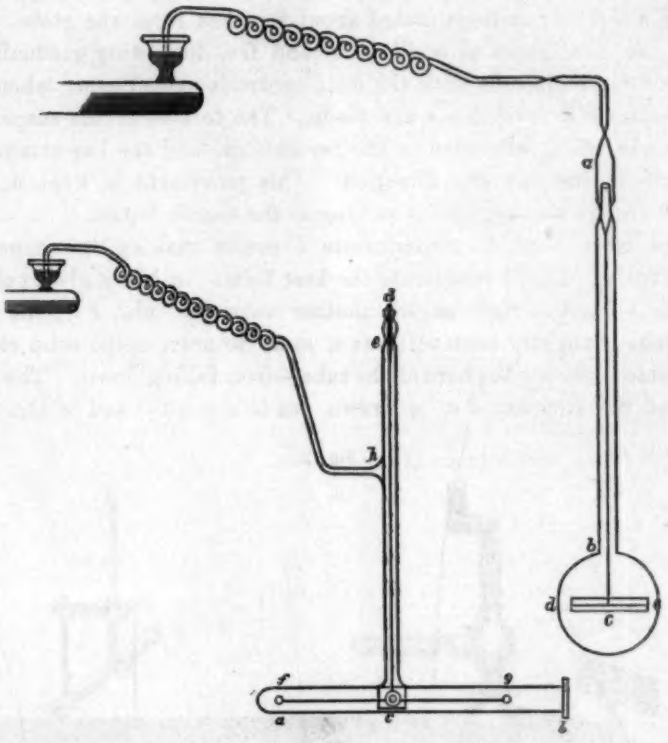


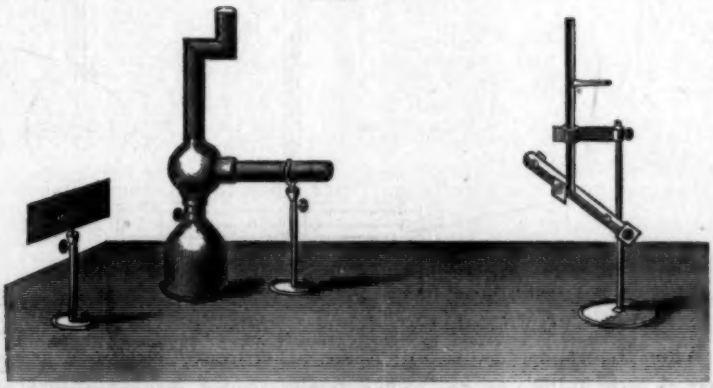
Fig. 4.

When the apparatus is full of air at ordinary pressure, a ray of heat or light falling on one of the extremities of the bar of pith gives a movement indicating attraction. When the apparatus is exhausted until the barometric gauge shows a depression of 12 millims. below the barometer, neither attraction nor repulsion results when radiant light or heat falls on the pith, but when the vacuum is as good as the pump will produce, strong repulsion is shown when radiation is allowed to fall on one end of the index. An apparatus of this kind constructed with the proper precautions, and sealed off when the vacuum is perfect, is so sensitive to heat that a touch with the finger

on a part of the globe near one extremity of the pith, will drive the index round over 90°, while it follows a piece of ice as a needle follows a magnet. With a large bulb, very well exhausted and containing a suspended bar of pith, a somewhat striking effect is produced when a lighted candle is placed about 2 inches from the globe. The pith bar commences to oscillate to and fro, the swing gradually increasing in amplitude until the dead centre is passed over, when several complete revolutions are made. The torsion of the suspending fiber now offers resistance to the revolutions, and the bar commences to turn in the opposite direction. This movement is kept up with great energy and regularity as long as the candle burns.

For more accurate experiments I prefer making the apparatus differently. Fig. 4 represents the best form. *a b* is a glass tube, to which is fused at right angles another narrower tube, *c d;* the vertical tube is slightly contracted at *e*, so as to prevent the solid stopper *d*—which just fits the bore of the tube—from falling down. The lower end of the stopper, *d e*, is drawn out to a point; and to this is ce-

Fig. 5.



mented a fine glass thread about 0·001 inch diameter, or less, according to the torsion required.*

At the lower end of the glass thread an aluminium stirrup and a concave glass mirror are cemented, the stirrup being so arranged that

* Some of the glass fibers used in these torsion balances are so fine, that when one end is held between the fingers, the other portion floats about like a spider's thread and frequently rises until it takes a vertical position.

it will hold a beam, *f g*, having masses of any desired material at the extremities. At *c* in the horizontal tube is a plate glass window cemented on to the tube. At *b* is also a piece of plate glass cemented on. Exhaustion is effected through a branch tube, *h*, projecting from the side of the upright tube. This is sealed by fusion to the spiral tube of the pump. The stopper *d e* and the glass plates *c* and *b* are well fastened with a cement of resin and beeswax.

The advantage of a glass-thread suspension is that the beam always comes back to its original position.

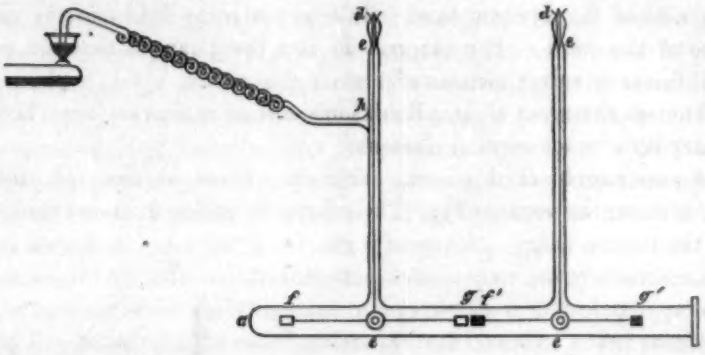
An instrument of this sort, perfectly exhausted and then sealed off, is shown at work in Fig. 5. It has pith plates at the extremities of the torsion beam. A ray of light from the lamp is thrown on to the central mirror, and thence reflected on to the graduated scale. The approach of a finger to either extremity of the beam causes the luminous index to travel several inches, showing repulsion. A piece of ice brought near causes the spot of light to travel as much in the opposite direction. In order to ensure the luminous index coming accurately back to zero, extreme precautions must be taken to keep all extraneous radiation from acting on the torsion-balance. The whole apparatus is closely packed round with a layer of cotton-wool about 6 inches thick, and outside this is arranged a double row of Winchester quart bottles filled with water, spaces only being left for the radiation to fall on the balance and for the index ray of light to get to and from the mirror.

However much the results may vary when the vacuum is imperfect, with an apparatus of this kind they always agree among themselves when the residual gas is reduced to the minimum possible; and it is of no consequence what this residual gas is. Thus, starting with the apparatus full of various vapors and gases, such as air, carbonic acid, water, iodine, hydrogen, ammonia, etc., there is not found at the highest rarefaction, any difference in the results which can be traced to the residual gas. A hydrogen vacuum appears the same as a water or an iodine vacuum.

The neutral point for a thin surface of pith being low, and that for a moderately thick piece of platinum being high, it follows that at a rarefaction intermediate between these two points pith will be repelled, and that platinum will be attracted by the same beam of radiation. This has been proved experimentally. An apparatus

showing simultaneous attraction and repulsion by the same ray of light is illustrated in Fig. 6.

Fig. 6.



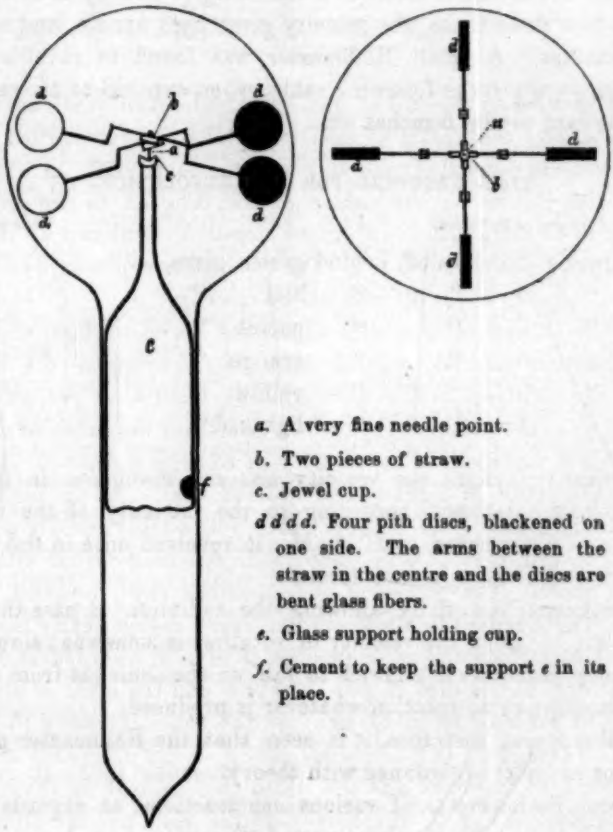
The pieces *f g* on the end of one beam consist of platinum foil exposing a square centimeter of surface, whilst the extremities *f' g'* on the other beam consist of pith plates of the same size. A wide beam of radiation thrown in the centre of the tube on to the plates *g f'* causes *g* to be attracted and *f'* to be repelled, as shown by the light reflected from the mirrors, *c c'*. The atmospheric pressure in the appartus is equal to about 40 millims. of mercury.

In a torsion apparatus similar to the one shown in Figs. 4 and 5, I have submitted variously colored discs to the action of the different rays of the spectrum. The most striking results, as yet, have been obtained when the different rays of the spectrum were thrown on white and on black surfaces. The result was to show a decided difference between the action of light and of radiant heat. At the highest exhaustions dark heat from boiling water acts almost equally on white pith and on pith coated with lampblack, repelling either with about the same force. The action of the luminous rays, however, is different. These repel the black surface more energetically than they do the white surface and consequently, if in such an apparatus as is shown at Fig. 4, one disc of pith is white and the other is black, an exposure of both of them to light of the same intensity will cause the torsion thread to twist around, owing to the difference of repulsion exerted on the black and the white surface. If, in the bulb apparatus shown in Fig. 3, the halves of the pith bar are alternately white and lampblacked, this differential action will produce rapid

rotation in one direction, which keeps up until stopped by the torsion of the suspending fiber.

Taking advantage of this fact I have constructed an instrument which I have called the Radiometer, shown in section and plan at Figs. 7 and 8. It consists of four arms, of some light material, suspended on a hard steel point resting in a jewel cup, so that the arms are able to revolve horizontally upon the centre pivot, in the same manner as the arms of Dr. Robinson's anemometer revolve. To the extremity of each arm is fastened a thin disc of pith, white on one side and lampblacked on the other, the black surfaces of all the discs facing the same way. The whole is enclosed in a thin glass

Fig. 7. Fig. 8.



a. A very fine needle point.

b. Two pieces of straw.

c. Jewel cup.

d d d d. Four pith discs, blackened on one side. The arms between the straw in the centre and the discs are bent glass fibers.

e. Glass support holding cup.

f. Cement to keep the support *e* in its place.

globe, which is then exhausted to the highest attainable point and hermetically sealed.

The arms of this instrument rotate with more or less velocity under the action of radiation, the rapidity of revolution being directly proportional to the intensity of the incident rays. Placed in the sun or exposed to the light of burning magnesium, the rapidity is so great that the separate discs are lost in a circle of light. Exposed to a candle 20 inches off another instrument gave one revolution in 182 seconds; with the same candle placed at a distance of 10 inches off the result is one revolution in 45 seconds; and at 5 inches off one revolution was given in 11 seconds. Thus it is seen that the mechanical action of radiation is inversely proportional to the square of the distance. At the same distance 2 candles give exactly double, and 3 candles give three times, the velocity given by 1 candle, and so on up to 24 candles. A small Radiometer was found to revolve at the velocities shown in the following table, when exposed to the radiation of a standard candle 5 inches off.

TIME REQUIRED FOR ONE REVOLUTION.

Source of Radiation.	Time in Seconds.
1 candle, 5 inches off, behind green glass, ...	40
" 5 " " blue "	38
" 5 " " purple "	28
" 5 " " orange "	26
" 5 " " yellow "	21
" 5 " " light red "	20

In diffused daylight the velocity was one revolution in from 1·7 seconds to 2·3 seconds, according to the intensity of the incident rays. In full sunshine, at 10 A. M., it revolved once in 0·3 second, and at 2 P. M., once in 0·25 second.

When heat is cut off by allowing the radiation to pass through a thick plate of alum, the velocity of rotation is somewhat slower, and when only dark heat is allowed to fall on the arms (as from a vessel of boiling water) no rotation whatever is produced.

In all respects, therefore, it is seen that the Radiometer gives indications in strict accordance with theory.

Several radiometers, of various constructions as regards details, but all depending on the above-named discovery, have been exhibited

at the Royal Society, where their novelty and unexpected indications excited a considerable amount of interest.

This form of instrument is of too recent a construction for me to be able to do more than draw brief attention to a few of the many uses for which it is applicable.

By timing the revolutions of the instrument when exposed direct to a source of light—a candle, for instance—the total radiation is measured. If a screen of alum is now interposed, the influence of heat is almost entirely cut off, the velocity becomes proportionately less, and the instrument becomes a photometer. By its means photometry becomes much simplified; flames the most diverse may readily be compared between themselves or with other sources of light; a "standard candle" can now be defined as one which at x inches off, causes the radiometer to perform y revolutions per minute, the values of x and y having previously been determined by comparison with some ascertained standard; and the statement that a gas-light is equal to so many candles, may, with more accuracy, be replaced by saying that it produces so many revolutions.

To photographers the radiometer will be invaluable. As it will revolve behind the orange-colored glass used for admitting light into the so-called dark room, it is only necessary to place one of these instruments in the window to enable the operator to see whether the light entering his room is likely to injure the sensitive surfaces there exposed; thus, having ascertained by experience that his plates are fogged, or his paper injured, when the revolutions exceed, say, ten a minute, he will take care to draw down an extra blind when the revolutions approach that number. Still more useful will the radiometer be in the photographic gallery. Placing an instrument near the sitter at the commencement of the day's operations, it is found that, to obtain a good negative, the lens must be uncovered—not for a particular number of seconds—but during the time required for the radiometer to make, say, twenty revolutions. For the remainder of the day, therefore, assuming his chemicals not to vary, the operator need not trouble himself about the variation of light; all he has to do is to watch the radiometer and expose for twenty revolutions, and his negatives will be of the same quality,* although at one time it may have taken

* In this brief sketch I omit reference to the occasions in which the ultra violet rays diminish in a greater proportion than the other rays.

five minutes, and at another not ten seconds, to perform the allotted number.

I have long been experimenting in the endeavor to trace some connection between the movements of attraction and repulsion, above alluded to, and the action of gravitation in Cavendish's celebrated experiment. The investigation is not sufficiently advanced to justify further details, but I will give here an outline of one of the results.

I find that a heavy metallic mass, when brought near a delicately suspended light ball, attracts or repels it under the following circumstances:—

I. *When the ball is in air of ordinary density.*

a. If the mass is *colder* than the ball, it *repels* the ball.
b. If the mass is *hotter* than the ball, it *attracts* the ball.

II. *When the ball is in a vacuum.*

a. If the mass is *colder* than the ball, it *attracts* the ball.
b. If the mass is *hotter* than the ball, it *repels* the ball.

The density of the medium surrounding the ball, the material of which the ball is made, and a very slight difference between the temperatures of the mass and the ball, exert so strong an influence over the attractive and repulsive force, and it has been so difficult for me to eliminate all interfering actions of temperature, electricity, etc., that I have not yet been able to get distinct evidence of an independent force (not being of the nature of heat or light) urging the ball and the mass together.

Experiment has, however, shown me that, whilst the action is in one direction in dense air, and in the opposite direction in a vacuum, there is (as I have already pointed out in the experiments described in the commencement of this paper) an intermediate pressure at which differences of temperature appear to exert little or no interfering action. By experimenting at this critical pressure, and at the same time taking all the precautions which experience shows are necessary, it would seem that such an action as was obtained by Cavendish, Reich, and Baily, should be rendered evident.

It is not unlikely that in the experiments here recorded may be found the key of some as yet unsolved problems in celestial mechanics.

In the sun's radiation passing through the quasi vacuum of space, we have the radial repulsive force, possessing successive propagation, required to account for the changes of form in the lighter matter of comets and nebulæ, and we may learn by that action, which is rapid and apparently fitful, to find the cause in those rapid bursts which take place in the central body of our system; but until we measure the force more exactly we shall be unable to say how much influence it may have in keeping the heavenly bodies at their respective distances.

So far as repulsion is concerned, we may argue from small things to great, from pieces of pith up to heavenly bodies; and we find that the repulsion shown between a cold and warm body will equally prevail, when for melting ice is substituted the cold surface of our atmospheric sea in space, for a lump of pith a celestial sphere, and for an artificial vacuum a steller void.

Throughout the course of these investigations I have endeavored to remain unfettered by the hasty adoption of a theory, which, in the early stages af an inquiry, must almost of necessity be erroneous. Some minds are so constituted that they seem impelled to form a theory on the slightest experimental basis. There is then great danger of their becoming advocates, and unconsciously favoring facts which seem to prove their preconceived ideas, and neglecting others which might oppose their views. This is unfortunate, for the mind should always be free to exercise the judicial function, and give impartial weight to every phenomenon which is brought it. *Any* theory will account for *some* facts; but only the true explanation will satisfy *all* the conditions of the problem, and this cannot be said of any theory which has yet come to my mind.

My object at present is to ascertain facts, varying the conditions of each experiment so as to find out what are the necessary and what the accidental accompaniments of the phenomena. By working steadily in this manner, letting each group of experiments point out the direction for the next group, and following up as closely as possible, not only the main line of research, but also the little by-lanes which often lead to the most valuable results, after a time the facts will group themselves together and tell their own tale; the conditions under which the phenomena invariably occur will give the laws; and the theory will follow without much difficulty. The eloquent language of Sir Humphry Davy contains valuable advice, although in

terms somewhat exaggerated. He says,—"When I consider the variety of theories which may be formed on the slender foundation of one or two facts, I am convinced that it is the business of the true philosopher to avoid them altogether. It is more laborious to accumulate facts than to reason concerning them; but one good experiment is of more value than the ingenuity of a brain like Newton's."

A NEW METHOD OF USING PAPER IN PLACE OF GLASS FOR NEGATIVES IN DRY-PLATE PHOTOGRAPHY.

By Leon Warnerke.*

All photographers are aware that photography out of the studio, with the systems now employed, presents certain difficultics which make the process of taking a photograph anything but pleasant. Having, in my photographic excursions, experienced all these inconveniences, I adopted from time to time different improvements; and having now arrived at a very satifactory solution of that all-important question for every photographer engaged out of the studio, I intend to give a full description of my method of working, and illustrate it by practical demonstration.

I scarcely need discuss the question whether the wet or dry system is to be employed for landscape photography. Owing to the great perfection reached in the preparation of collodion and gelatine emulsions, my choice is made, without hesitation, in favor of the dry system.

The first obstruction encountered is the material employed at present for the support to the sensitive film. Glass, notwithstanding the last extremely important discovery of M. de la Bastie, possesses many disadvantages when used in out-door photography. 1. It is heavy. 2. It is bulky in itself, and more so from the necessity of leaving empty space between the plates to prevent contact with the sensitive surface; and, again, from the necessity of having some kind of box

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*Communicated to the South London Photographic Society, at their meeting, June, 1875.

for storing. 3. It is brittle, and consequently requires extra care in transport. But the drawbacks are too numerous to enumerate. They are visible to every photographer, and I hope that experiments I have to perform, while showing the superiority of my new system, will render the disadvantages of glass more salient.

My principal improvement upon the old system is the substitution of paper, cloth, or any flexible material for glass, as support for the sensitive film. In my early experiments (made some five years ago) I applied simply bromized collodion to paper of fine texture sized with starch. But when it was used without substratum, prolonged development or further intensification occasioned discoloration of the paper by the action of the pyrogallic acid, and it consequently was regarded by myself as unsuccessful. But I cannot omit to mention it on the present occasion, for the very important observation made that bromized collodion in contact with the paper is incomparably more sensitive than the same in contact with glass, gelatine, india-rubber, or dammar varnish. The paper used by me was Steinbach's photographic. My experiments were made a long time before Mr. Bolton published his excellent washed emulsion process, so my collodion was made from—

Sulphuric ether, ...	4 ounces.
Alcohol, ...	4 "
Solution of bromine 1 dr. in alcohol 1 oz., .	20 minims.
Suitable pyroxyline, ...	40 grains.
Nitrate of silver (in hot alcohol) or equivalent of oxide of silver, ...	80 grains.

Neither preservative nor washing was necessary.

My next step was using a gelatine substratum between the paper and bromized collodion. In that and in the former case, to avoid discoloration, the developer was free from water. After exposure, the sensitive surface was flowed with a solution of—

Pyrogallic acid, ...	30 grains.
Alcohol, ...	1 ounce.

The excess was returned to the bottle for future use, and the following solution was immediately applied:—

Alcohol, ...	1½ ounces.
Solution of bromine 1 dr. in alcohol 1 ounce,	10 minims.
Strongest ammonia, ...	2 drachms.

The negative, when finished, was put on the glass, immersed in hot water, and the temporary paper support peeled off. Further experiments prove that great simplification and excellence are secured by the following method:

Preparation of the Negative Film.—I take a sheet of white enameled paper, bend all the sides to form a shallow dish, put it on a glass plate of suitable size, pour in the centre some plain collodion to which a small quantity of paraffine in alcohol was added, and return the excess, after distribution and usual rocking, to the bottle. This, when dry, will leave the paper very easily; but, to avoid this premature occurrence, lines are made with ruling pen or brush and asphalt varnish round the sheet; or, if it is to be cut, each plate is to be delineated with varnish. When this thin coating of collodion is dry, a solution of india-rubber in benzine is applied in a similar way. When dry, another coating of the following collodion is applied.

Ether, ...	20 ounces.
Alcohol, ...	40 "
Castor oil, ...	1 ounce.
Pyroxyline, ...	1 "

After drying, another india-rubber coating, and, lastly, sensitive bromized, bromo-iodo-chloro, or any of the washed collodion emulsions, is applied. When gelatine emulsion is preferred, the last india-rubber coating is omitted. I find the film is equally good when, after first coating of the collodion and paraffine, the following solution of gelatine is applied:—

Gelatine, ...	1 ounce.
Sugar, ...	1 drachm.
Glycerine, ...	½ "
Water, ...	*quant. suff.*

After it is dry, coatings with collodion and india-rubber follow, and lastly the sensitive emulsion.

In preparing the film, I prefer to build it from several thin coatings, instead of one of requisite thickness, because in that way I can avoid irregularities in thickness occasioned by curling of the paper. For the same reason draining of the solution is made each time from a different corner.

The prepared negative film, with its supporting paper, is cut to the desired size, interleaved with tissue paper for extra security, and preserved from light for use.

Exposure.—For large plates the film is exposed in the usual dark slide behind the glass plate. I choose the glass plate the same thickness as the ground glass in the focussing-frame, and, after reversing the last, I have the sensitive and focussing surfaces to coincide. For small plates, from 6½ by 8½ downwards, I prefer to avoid the use of the glass plate, and attach the paper with sensitive film to some rigid support. Mounting boards answer the purpose very well; but when even this inconsiderable thickness is objectionable, ferrotype plates are an excellent substitute. Negative films with supporting ferrotype plates are so thin that in my excursions last summer I was able to put twenty of these plates in every dark slide; and having with me Howard's tent, attachable to the camera stand, in three dark slides sixty negatives were taken without necessity to repair home, or to have a plate box for those sixty plates.

Development.—For the development, I have to detach one corner of the film with a penknife, and, holding it with two fingers, all the film can be easily detached from the supporting enameled paper.

After this, it is attached to a glass plate of the same size by means of a few drops of water. From that moment the development of the negative is proceeded with in the manner familiar to every photographer. In fact, the film is attached so firmly to the glass plate that there is not the slightest difference in the behavior of that and the old glass plates.

After development, fixing, and washing, some blotting paper is applied to remove the last drop of water. This mode of drying—provoking shuddering in the followers of the old glass system—need not be feared with my films. The final drying—especially when gelatine is used in the formation of the supporting film—must be executed under light pressure, between blotting-paper, in a book or otherwise.

If convenient, it can be dried on the glass plate and varnished, avoiding varnishes requiring heating of the plate; but there is no necessity for varnishing, except to facilitate retouching.

In this stage I have used the process for the last two years with invariable success, and have hundreds of negatives to testify it.

But I must confess I am subject to all the human imperfections. We are never satisfied with what we possess; and this spring, waiting for longer and brighter summer days, and planning my new excursions, the thought of carrying in my pocket Howard's tent, and the

prospect of plunging my head into that tent for changing each plate after the exposure, looked to me an unbearable torture. For consolation I retired to my work room, and, after some time, succeeded in preparing the slide which is intended to remove the last of the impedimenta in my way.

The Dark Slide.—The principal component parts of the new dark slide are two wooden rollers, on one of which the sensitive film, with its supporting paper, or without, is wound, and there is room enough for one hundred negatives. These rollers are placed in a horizontal position within the dark slide, one near the top, and the other near the bottom. Each roller has a metal head on the outside of the slide, by which it can be rotated; by means of these heads the ribbon of sensitive film can be drawn from one roller and wound, after exposure, on the other roller. To secure perfect flatness there is attached to each head a binding screw, permitting the stretching the film smooth when it is in position. A darkened glass plate is fixed near the front of the slide in the plane corresponding with the focussing surface, this glass plate guides the sensitive film in its progress from one roller to the other, and secures its proper position in the focus of the lens.

The back of the dark slide is closed by a hinged door, and the front has a sliding shutter.

Before the sensitive ribbon is attached to the roller it is divided into sections, corresponding with the size of the plates, by black lines drawn in pencil or otherwise, and each section is numbered.

In the sliding shutter is a little window secured with orange glass and spring metallic shutter. Through the orange glass I am able to observe the black lines forming divisions between the plates and corresponding numbers. This permits me to judge of the proper position of each consecutive plate, and tells me which plate is to be exposed; and if any imperfection was observable, which plate to avoid.

The production of negatives in the field with the aid of these improvements is a real enjoyment, because all the hard work is removed, and advantages gained over the old system are numerous.

Volume and weight of plates and apparatus are diminished.

Chance of breakage there is none; chance of abrading the sensitive surface is diminished. I ascribe to the flexibility of the support the greater amount of resistance to rough treatment my film offers.

There is no blurring possible. In application to the panoramic camera, what can offer facility similar to the new film? All costly cylindrical plates and special printing frames are useless; the sensitive film can take any shape in the dark slide, but will be flat in the printing frame.

For printing in carbon, and for all processes requiring reversed negatives, the film negative is ready without preparation. For printing stereoscopic negatives transposition is easy.

For storing negatives, no room, no boxes, or shelves are necessary. Film negatives are not destroyed by atmospheric influences.

Lastly, who can with the glass system, while going to distant lands, dream of taking one thousand plates for his long excursion? But with my film, that number, or one still larger, would not increase the weight of the traveler's luggage more than by a few ounces, and by a few inches the volume.

When I look to the future, the circle of the beneficial effect still widens.

Pliability of the sensitive film can alter optical conditions of our apparatus. Our lenses will be smaller. Definition more perfect. Distortion, spherical aberration, and other optical imperfections diminished. Aperture increased, and consequently exposure shortened.

I conclude with another less important improvement. I do not like the black cloth we use to cover our head when focussing. It gives a mysterious appearance to the operator, and increases the curiosity of the passers-by. Very often it conspires with the wind, without any respect for the head-dress of the operator, or stability of the camera.

In my apparatus I substituted a looking-glass inclined 45° to the ground glass. The image appears in right position, is much brighter, and when shut the frame containing the mirror offers a protection to the ground glass, taking infinitely less room than the black cloth.

Explosion in a Drug Store in Boston.—The *Boston Journal of Chemistry* is of the opinion, the extraordinary explosion which occurred several weeks ago, at the store of Mr. G. D. Dows, in Washington street, in that city, was caused by the vapor of ether, the proprietor having stated that he had in the building, several bottles holding five pounds each of this dangerous agent.